Supplementary Materials

S1 Reda's Path Planning Benchmark 2024 (RP2B-24): Model configurations for the path planning scenarios

Table S1: The model configurations for the path planning scenarios for the types: Open field, single obstacle, and multiple obstacle cases.

Category	Config	Label	Start (xs, ys)	End (xt, yt)	# Obs	Obst. X	Obst. Y	Obst. Radius
Open Field	1	M1	(-7,-10)	(-6, 10)	0	None	None	None
Single	1	M2	(0, 0)	(4, 6)	1	2	3	1.5
Obstacle	2	M3	(4, 2)	(6, 8)	1	5	5	2.5
Multi	1	M4	(-8.5, -6)	(1, 5)	2	-5, -2	-5, 2	2.5, 2
Obstacles	2	M5	(-2, -2)	(10, 10)	3	1.5, 6, 6	2, 2, 7	2.3, 1.5, 2
	3	M6	(0, 0)	(4, 6)	3	1.5, 4.0, 1.2	4.5, 3.0, 1.5	1.5, 1.0, 0.8
	4	M7	(-10, -10)	(10, 10)	5	-7.5, -3.75, 0, 3.75, 7.5	-7.5, -3.75, 0, 3.75, 7.5	2, 2, 2, 2, 2
	5	M8	(0, 0)	(9, 8)	4	1.5, 3.5, 5.5, 7.5	1.5, 4.5, 2.5, 5.5	1, 1, 1, 1
	6	M9	(-10, -10)	(10, 10)	4	2, 4, 6, 8	2, 8, 2, 8	1.6, 1.6, 1.6, 1.6
	7	M10	(-2, -1)	(10, 10)	4	2, 8, 2, 8	2, 2, 8, 8	2.5, 1.5, 2, 1.5
	8	M11	(-6, -5)	(7, 4)	5	-4, 4, -4, 4, 0	-2, -2, 2, 2, 0	1.5, 1.5, 1.5, 1.5, 2
	9	M12	(-8, -8)	(8, 8)	6	-5, -1, 4, -5, -1, 4	-3, -3, -3, 3, 3, 3	1.5, 1.5, 1.5, 1.5, 1.5, 1.5
	10	M13	(-10, -10)	(10, 10)	5	-7.5, -6.75, -0.5, 7.2, 6	-6.5, 0.5, 0.5, -0.5, 5.5	2.2, 2.6, 3, 2, 3
	11	M14	(-8, -8)	(8, 8)	7	0, 0, 0, -4, 4, -4, 4	-6, 0, 6, -2, -2, 2, 2	1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5
	12	M15	(-8, -8)	(9, 8)	9	-5, 1, 7, -5, 1, 7, -5, 1, 7	-5, -5, -5, 0, 0, 0, 5, 5, 5	1.4, 1.9, 1.4, 1.9, 1.9, 1.9, 1.4, 1.9, 1.4
	13	M16	(-8, -4.5)	(8, 8)	11 11	6, 6, 6, -6, -6, -6, 0, 0, 2.1, -2.1, 0	2, 6, -2, 2, 6, -2, -4, 7, 0, 0, 3	1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5

Table S1 (Cont.): The model configurations for the path planning scenarios for the types: narrow passages.

Category	Config	Label	Start (xs, ys)	End (xt, yt)	# Obs	Obst. X	Obst. Y	Obst. Width	Obst. Height
Narrow	1	M17	(0, -2.5)	(1.5, 0)	3	1.5, -0.8, 3	-2, 0.3, -5	1.5, 1.5, 1.5	3, 3, 3
Passage	2	M18	(2, -9.5)	(7, 4)	4	4.5, 2.2, 4.5, 2.2	-8, -4, 0, 4	1.5, 1.5, 1.5, 1.5	4, 4, 4, 4
	3	M19	(2.5, 1.5)	(2.5, 2.5)	2	2, 3	3.3, 2	0.2, 2	2, 0.4
	4	M20	(1.85, 6.5)	(2.35, 4)	2	2.45, 1.25	6.75, 5	0.4, 1.8	3, 1
	5	M21	(0, 1.1)	(2, 6)	3	0.5, -1, 2	-1, 3, 4	0.5, 3, 3	6, 0.5, 0.5
	6	M22	(3.2, 2.8)	(4, 6)	4	4, 2, 3.2, 4	2, 4, 6, 8	0.5, 3.5, 0.5, 0.5	7, 0.5, 2, 2
	7	M23	(0, 0)	(7, 9)	4	4, 2, 2, 5	2, 4, 6, 6	0.5, 3, 0.5, 1	7, 0.5, 2, 2
	8	M24	(3, 2)	(5.25, 6.5)	5	2, 4, 2, 5, 3	2, 2, 6, 6, 4	0.5, 0.5, 2, 2, 1	2, 2, 0.5, 0.5, 1.8
	9	M25	(0, 0)	(5, 4)	5	1, 5.4, 2, 4, 3.5	2, 2, 5.5, 4.5, 1	1, 0.5, 2, 1, 1.5	5, 2, 0.5, 2.5, 0.5
	10	M26	(0, 0)	(10, 6)	5	2, 2, 5, 7, 7	1, 4, 3, 1, 5	6, 1, 1, 1, 1	1, 2, 2, 2, 1
	11	M27	(0, 0)	(10, 10)	9	1, 2, 3, 4, 5 6, 7, 8, 9	2, 5, 8, 1, 4 7, 2, 5, 8	1, 1, 1, 1, 1 1, 1, 1, 1	2, 2, 2, 2, 2 2, 2, 2, 2
	12	M28	(1.75, 0)	(6, 6.5)	5	1, 2.5, 4, 6, 7.5	1, 1, 4, 0.5, 6	1, 1, 1.5, 1.8, 1	7, 3, 7, 8.5, 3
	13	M29	(0, 0)	(5, 4)	6	2, 3, 1, 5, 7, 5	1, 4, 7, 7, 5, 2	2, 3, 2, 2, 1, 3	3, 3, 2, 32, 3, 1
	14	M30	(2.5, 0)	(6, 4)	7	1.5, 4, 3, 7, 9, 6, 7	1, 1, 4, 4, 2, 7, 0	1.5, 1, 3, 1, 2, 3, 1.5	8, 4, 2, 5, 6, 2, 2
	15	M31	(5, -9)	(2, 9)	6	2, 5, 2, 5, 2, 5	-9, -6, -3, 1, 5, 9	3, 3, 3, 3, 3, 3	2, 2, 2, 2, 2, 2
	16	M32	(5, -9)	(3, 4)	8	2, 5, 2, 5, 2, 5, 2, 5	-8, -6, -4, -2, 2, 4, 6, 8	2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8	1.3, 1.3, 1.3, 1.3, 1.3, 1.3, 1.3, 1.3
	17	M33	(-6.5, -4)	(8.1, 8.8)	12	5.5, 8.5, 6.5, 8.5, 6.5, 8.5, 6.5, 8.5, 6.5, 8.5, 6.5, 8.5	-8,-7, -6, -4, -2, 0, 2, 4, 6, 6.7, 8, 10	2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2	1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5
	18	M34	(-10, -5)	(-2.2, 7.8)	10	-7, -4, -7, -4, -7, -4, -7, -4, -7, -4	-8, -6, -4, -2, 0, 2, 4, 6, 8, 10	4, 4, 4, 4, 4, 4, 4, 4, 4, 4	1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.5
	19	M35	(-4, -5)	(7, 3.4)	14	-3,-3, -1.8, -1, -1, 0.3,1.5, 1.8, 3, 4 4.1, 5.7, 5.5, 7.5	-1.5, 2, -4, 0, 4, -2, 2, -4.5, 0, 4.5, -2.3, 2, -4.2, 0	1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	2, 4, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2
	20	M36	(2, 4)	(6, 9)	10	1, 1, 2, 3, 3, 4, 5, 5, 6, 7	3, 7, 1, 5, 9, 3, 7, 1, 5, 9	1, 1, 1, 1, 1, 1, 1, 1, 1, 1	4, 4, 2, 2, 2, 2, 2, 2, 2, 2
	21	M37	(3, 1)	(9, 7)	14	1, 1, 2, 3.5, 3, 4, 5, 5, 6, 7, 7, 8, 9, 9.2	1, 5, -1, 3, 7, 1, 5, -1.3, 3, 7, 0.8, 5, -1.5, 2.3	1, 1, 1, 1.5, 1, 1.3, 1.2, 1, 1.2, 2, 1, 1, 1.5, 1.5	4, 4, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2

Table S1 (Cont.): The model configurations for the path planning scenarios for the types: maze-like cases.

Category	Config	Label	Start (xs, ys)	End (xt, yt)	# Obs	Obst. X	Obst. Y	Obst. Width	Obst. Height
Maze-Like	1	M38	(0, 0)	(8, 8)	2	2, 6	2, 6	0.1, 0.1	6, 6
	2	M39	(0, 0)	(10, 10)	6	2, 4, 4 6, 8, 8	2, 6, 2 4, 2, 8	0.1, 0.1, 0.1 0.1, 0.1, 0.1	7, 3, 0.1 5, 6, 0.1
	3	M40	(0, 0)	(8, 8)	6	2, 2, 4 4, 6, 6	1, 5, 1 5, 1, 5	0.1, 0.1, 0.1 0.1, 0.1, 0.1	4, 2, 4 2, 4, 2
	4	M41	(0, 0)	(9.5, 8.2)	10	1, 1, 3, 3, 5, 5, 7, 7, 9, 9	2, 6, 2, 6, 2, 6, 2, 6, 2, 6	0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1	3.8, 1, 3.8, 1, 3.8, 1, 3.8, 1, 3.8, 1
	5	M42	(0, 0)	(10, 8)	8	2, 2, 4, 4, 6, 6, 8, 8	2, 6, 1, 5, 2, 6, 1, 5	0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1	3, 3, 2, 2, 3, 3, 2, 2
	6	M43	(0, 0)	(10, 10)	8	2, 2, 4, 4, 6, 6, 8, 8	2, 8, 1, 5, 1, 5, 2, 8	0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1	5, 1, 3, 3, 3, 3, 5, 1
	7	M44	(-5, -5)	(4, 2)	12	-4, -4, -2, -2, 0, 0, 2, 2, 4, 4, 6, 6	-4, 4, -4, 2, -4, 4, -4, 3, -2, 4, -4, 2	0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1	6, 6, 2, 4, 7, 2, 4, 5, 6, 2, 2, 4
	8	M45	(-2, -7)	(10, 7)	14	0, 0, 0, 2, 2, 4, 4, 5.5, 6, 6, 6, 8, 8, 8	-4, -0.2, 4, -4, 3.5, -3.5, 1, 6, -4, 0, 3, -2, 2, 6.2	0.1, 0.1, 2.5, 0.1, 0.1, 0.1, 2.5, 3, 0.1, 3, 0.1, 0.1, 0.1, 0.1	4, 1.5, 0.2, 2, 4, 3, 0.2, 0.2, 3, 0.2, 1.5, 2.5, 1.5, 1.5
	9	M46	(0, -5)	(4, 3)	14	-3, -3, -3, -1, -1, -1, 1, 1, 3, 3, 3, 5, 5, 5	-3, 1, 5, -3, 1, 5, -3, 5, -3, 1, 5, -3, 1, 5	0.1, 2, 0.1, 3.2, 0.1, 0.1, 0.1, 2, 2, 3, 0.1, 0.1, 0.1, 0.1	3, 0.1, 3, 0.1, 3, 3, 7, 0.1, 0.1, 0.1, 4, 3.5, 3, 3
	10	M47	(-4, -4)	(4, -1)	14	-5, -5, -3, -3, -3, -1, -1, 1, 1, 2, 3, 3, 5, 4.3	-3, 3, -6, 0, 5, -3.5, 4, 0, 5, -6, -2, 2, -3, 2	0.1, 0.1, 3, 3, 3, 0.1, 0.1, 2, 4, 4.5, 0.1, 0.1, 0.1, 2	8, 4, 0.1, 0.1, 0.2, 6, 4, 0.1, 0.1, 0.1, 3.5, 3, 8, 0.1
	11	M48	(-5, -5)	(5, 3.7)	17	-6, -6, -6, -4, -4, -2, -2, -2, 0, 0, 2, 2, 2, 4, 4, 6, 6	-3, 3, 5, -3, 1.8, -6, 0, 5, -5, 3, -6, 0, 5, -5, 1.8, -3, 5	0.1, 2, 0.1, 3, 0.1, 2, 2, 3, 0.1, 0.1, 2, 2, 3, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1	9, 0.1, 3, 0.1, 2.5, 2.9, 2.9, 0.1, 6, 4, 2.9, 2.9, 0.1, 6, 2.5, 9, 3
	12	M49	(-2.5, 2.5)	(5, 0)	17	-6, -6, -6, -4, -4, -2, -2, -2, 0, 0, 2, 2, 2, 4, 4, 6, 6	-3, 3, 5, -3, 1.8, -6, 0, 5, -5, 3, -6, 0, 5, -5, 1.8, -3, 5	0.1, 2, 0.1, 3, 0.1, 2, 2, 3, 0.1, 0.1, 2, 2, 3, 0.1, 0.1, 0.1, 0.1, 0.1, 0.1	9, 0.1, 3, 0.1, 2.5, 2.9, 2.9, 0.1, 6, 4, 2.9, 2.9, 0.1, 6, 2.5, 9, 3
	13	M50	(-5, -4.6)	(5, 0)	20	-6, -4, -4, -6, -4, -4, -2, -2, -2, 0, 0, 0, 2, 2, 4, 4, 4, 2, 6, 6	-4, 0, 2, 4, -5, -2, -4, 0, 4, -6, -2, 1, -4, 0, -6, -2, 2, 4, -4, 4	0.1, 0.1, 3, 0.1, 0.1, 3, 2, 2, 2, 0.1, 0.1, 0.1, 2, 2, 3, 3, 3, 2, 0.1, 0.1	8, 2, 0.1, 3, 2, 0.1, 2, 2, 2, 2.2, 2.2, 2.2, 2, 2, 0.1, 0.1, 0.1, 0.1, 2, 8, 4



Figure S1: Model Configurations for the proposed library of the path planning scenarios. The obstacles are blue in colour, the start point is a yellow circle, and the endpoint is a green square. (Model M1 to M50)

S2 Objective Function: Other Types of Obstacles

S2.1 Penalty for circular obstacles

The b-th circular obstacle, denoted as C^b, is defined by its center (x_b, y_b) and radius r_b, as shown in Fig. S2. For the point-based penalty, the Euclidean distance d_i^b between the i-th path point (x_i, y_i) and the center of the b-th obstacle (x_b, y_b) is calculated using Eq. (S1). The point-based penalty p_i^b is then computed using Eq. (S2). If $d_i^b \geq r_b$, the path point is in a safe region, and p_i^b is set to zero. Otherwise, a collision occurs, and p_i^b is set to $1 - \frac{d_i^b}{r_b}$, making it inversely proportional to d_i^b.

$$d_i^b = \sqrt{(x_i - x_b)^2 + (y_i - y_b)^2} \tag{S1}$$

$$p_i^b = \begin{cases} 0, & \text{if } d_i^b \geq r_b \\ 1 - \frac{d_i^b}{r_b}, & \text{if } d_i^b < r_b \end{cases} \tag{S2}$$

The segment-based penalty $p_{\text{line},j}^b$ accounts for collisions between the b-th obstacle and the j-th line segment between two successive waypoints, denoted as $L_j = [(x_j, y_j), (x_{j+1}, y_{j+1})]$. The b-th circular obstacle is defined mathematically in Eq. (S3), and the penalty $p_{\text{line},j}^b$ is evaluated using Eq. (S4). If L_j intersects C^b, $p_{\text{line},j}^b$ is set to 1; otherwise, it is set to 0. The intersection is determined using the Circle-Line Intersection Test, detailed in Section S2.1.1.

$$C^b = \{(x, y) \mid (x - x_b)^2 + (y - y_b)^2 = r_b^2\}, \tag{S3}$$

$$p_{\text{line},j}^b = \begin{cases} 1, & \text{if } L_j \cap C^b \neq \emptyset, \\ 0, & \text{otherwise.} \end{cases} \tag{S4}$$

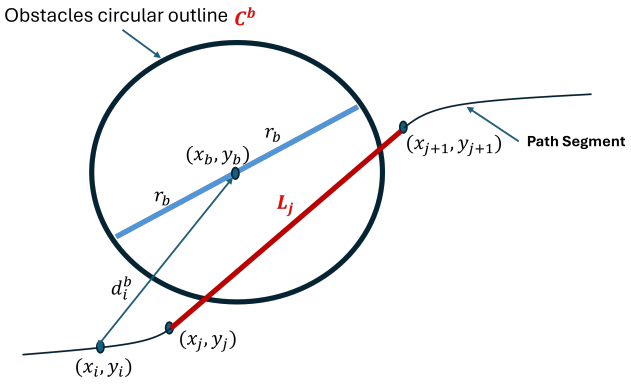


Figure S2: Illustrative figure shows circle obstacle and its parameters.

S2.1.1 Intersection of Line Segment with Circular Obstacle: Circle-Line Intersection Test

The intersection between a line segment $L_j = [(x_1, y_1), (x_2, y_2)]$ and a circular obstacle with center (c_x, c_y) and radius r can be determined as follows:

1. Circle Equation The circle is defined by:

$$(x - c_x)^2 + (y - c_y)^2 = r^2. \tag{S5}$$

2. Parametric Equation of the Line Segment The line segment L_j is parameterized as:

$$x(t) = x_1 + t(x_2 - x_1), \quad y(t) = y_1 + t(y_2 - y_1), \quad t \in [0, 1]. \tag{S6}$$

3. Substitute the Line Segment into the Circle Equation Substituting the parametric form of the line segment into the circle equation results in a quadratic equation:

$$at^2 + bt + c = 0, \tag{S7}$$

where:

$$a = (x_2 - x_1)^2 + (y_2 - y_1)^2, \tag{S8}$$

$$b = 2\big((x_2 - x_1)(x_1 - c_x) + (y_2 - y_1)(y_1 - c_y)\big), \tag{S9}$$

$$c = (x_1 - c_x)^2 + (y_1 - c_y)^2 - r^2. \tag{S10}$$

4. Compute the Discriminant The discriminant Δ of the quadratic equation is:

$$\Delta = b^2 - 4ac. \tag{S11}$$

- No intersection: If $\Delta < 0$, the line segment does not intersect the circle. - Possible intersection: If $\Delta \geq 0$, compute t_1 and t_2.

5. Solve for t_1 and t_2 The solutions for t are:

$$t_1 = \frac{-b - \sqrt{\Delta}}{2a}, \quad t_2 = \frac{-b + \sqrt{\Delta}}{2a}. \tag{S12}$$

6. Intersection Condition The line segment intersects the circle if:

$$0 \leq t_1 \leq 1 \quad \text{or} \quad 0 \leq t_2 \leq 1. \tag{S13}$$

7. Penalty Indicator The penalty term $p^b_{\text{line},j}$ for the intersection is defined as:

$$p^c_{\text{line},j} = \begin{cases} 1, & \text{if } 0 \leq t_1 \leq 1 \text{ or } 0 \leq t_2 \leq 1, \\ 0, & \text{otherwise.} \end{cases} \tag{S14}$$

S2.2 Penalty for rectangular obstacles

The point-based penalty p_i^b for rectangular obstacles is calculated differently. First, the boundaries (edges) of the rectangular obstacle, $x_{\min,b}$, $x_{\max,b}$, $y_{\min,b}$, and $y_{\max,b}$, are determined using Eq. (S15), where w_b and h_b are the obstacle's width and height, and (x_b, y_b) is its center. The normalized distance d_i^b between the i-th point and the closest edge of the b-th rectangular obstacle is then calculated using Eq. (S16).

If the i-th point lies outside the obstacle, p_i^b is set to zero. If the point lies inside the obstacle, p_i^b equals d_i^b, as defined in Eq. (S17). A point at any obstacle edge has $p_i^b = 0$, while a point at the center has $p_i^b = 1$, as all normalized distances to the edges are 1. The penalty increases as the point moves closer to the obstacle's center and further from any edge.

$$\begin{aligned} x_{\min,b} = x_b - \frac{w_b}{2}, x_{\max,b} &= x_b + \frac{w_b}{2} \\ y_{\min,b} = y_b - \frac{h_b}{2}, y_{\max,b} &= y_b + \frac{h_b}{2} \end{aligned} \tag{S15}$$

$$d_i^b = \min\left(\frac{|x_i - x_{\min,b}|}{\frac{w_b}{2}}, \frac{|x_i - x_{\max,b}|}{\frac{w_b}{2}}, \frac{|y_i - y_{\min,b}|}{\frac{h_b}{2}}, \frac{|y_i - y_{\max,b}|}{\frac{h_b}{2}} \right) \tag{S16}$$

$$p_i^b = \begin{cases} 0, & \text{if } x_i < x_{\min,b} \text{ or } x_i > x_{\max,b} \text{ or } y_i < y_{\min,b} \text{ or } y_i > y_{\max,b} \\ d_i^b, & \text{if } x_{\min,b} \le x_i \le x_{\max,b} \text{ and } y_{\min,b} \le y_i \le y_{\max,b} \end{cases} \tag{S17}$$

The segment-based penalty $p_{\text{line},j}^b$ represents the collision between the j-th line segment L_j and the edges of the b-th rectangular obstacle. Each edge of the rectangle, E_k^b, is indexed by $k \in 1, 2, 3, 4$, representing the bottom, top, left, and right edges, as defined in Eq. (S18). The intersection between L_j and any edge E_k^b is evaluated using Eq. (S19). If L_j intersects any edge E_k^b, the penalty $p_{\text{line},j}^b$ is set to 1; otherwise, it is set to 0. Fig. S3 illustrates this concept, and the intersection is validated using the orientation test based on the cross-product method, detailed in Section S2.2.1.

$$E_k^b = \begin{cases} [(x_{\min,b}, y_{\min,b}), (x_{\max,b}, y_{\min,b})], & k = 1 \text{ (bottom edge)} \\ [(x_{\min,b}, y_{\max,b}), (x_{\max,b}, y_{\max,b})], & k = 2 \text{ (top edge)} \\ [(x_{\min,b}, y_{\min,b}), (x_{\min,b}, y_{\max,b})], & k = 3 \text{ (left edge)} \\ [(x_{\max,b}, y_{\min,b}), (x_{\max,b}, y_{\max,b})], & k = 4 \text{ (right edge).} \end{cases} \tag{S18}$$

$$p_{\text{line},j}^b = \begin{cases} 1, & L_j \cap E_k^b \neq \emptyset, \ \exists k \in \{1, 2, 3, 4\}, \\ 0, & \text{otherwise.} \end{cases} \tag{S19}$$

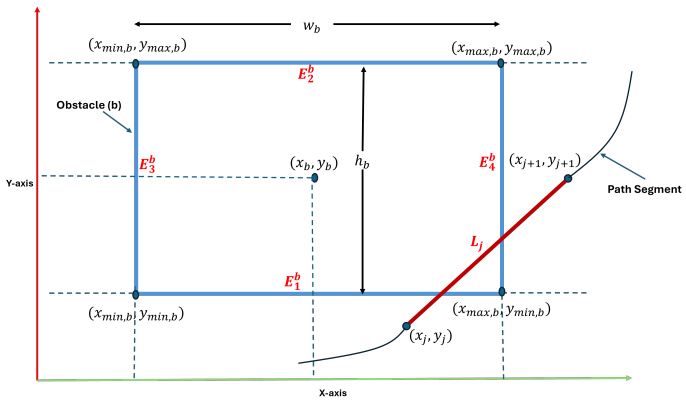


Figure S3: Illustrative Figure shows the segment-based penalty relationships in rectangular obstacles.

S2.2.1 Intersection of Line Segment with Rectangle Obstacle: Orientation Test

Cross-Product Test for Line Segment and Rectangle Edge

The *cross-product* between two vectors $\mathbf{u}$ and $\mathbf{v}$ in 2D is given by:

$$\mathbf{u} \times \mathbf{v} = u_x v_y - u_y v_x. \tag{S20}$$

For three points in 2D space (x_1, y_1), (x_2, y_2), and (x_3, y_3), define the vectors:

$$\mathbf{u} = \begin{bmatrix} x_2 - x_1 \\ y_2 - y_1 \end{bmatrix}, \quad \mathbf{v} = \begin{bmatrix} x_3 - x_1 \\ y_3 - y_1 \end{bmatrix}. \tag{S21}$$

The cross-product $\mathbf{u} \times \mathbf{v}$ measures the direction of the turn (positive for counterclockwise, negative for clockwise).

Edge Definition of Rectangular Obstacles

Each rectangle is defined by its four edges, indexed by $k \in \{1, 2, 3, 4\}$, representing the bottom, top, left, and right edges, respectively. For the b-th rectangle, the edges are expressed as:

$$E_k^b = \begin{cases} [(x_{\min,b}, y_{\min,b}), (x_{\max,b}, y_{\min,b})], & k = 1 \text{ (bottom edge)}, \\ [(x_{\min,b}, y_{\max,b}), (x_{\max,b}, y_{\max,b})], & k = 2 \text{ (top edge)}, \\ [(x_{\min,b}, y_{\min,b}), (x_{\min,b}, y_{\max,b})], & k = 3 \text{ (left edge)}, \\ [(x_{\max,b}, y_{\min,b}), (x_{\max,b}, y_{\max,b})], & k = 4 \text{ (right edge)}. \end{cases} \tag{S22}$$

Intersection Test

For a line segment $L_j = [(x_j, y_j), (x_{j+1}, y_{j+1})]$ and the k-th edge of the b-th rectangle $E_k^b = [(x_{k1}, y_{k1}), (x_{k2}, y_{k2})]$:

1. Define the vector for the edge:

$$\mathbf{e}_k^b = \begin{bmatrix} x_{k2} - x_{k1} \\ y_{k2} - y_{k1} \end{bmatrix}. \tag{S23}$$

2. Define the vector for the line segment:

$$\mathbf{l}_j = \begin{bmatrix} x_{j+1} - x_j \\ y_{j+1} - y_j \end{bmatrix}. \tag{S24}$$

3. Define the test points for the cross-product: - Test L_j with respect to E_k^b:

$$c_1 = \mathbf{e}_k^b \times \begin{bmatrix} x_j - x_{k1} \\ y_j - y_{k1} \end{bmatrix}, \quad c_2 = \mathbf{e}_k^b \times \begin{bmatrix} x_{j+1} - x_{k1} \\ y_{j+1} - y_{k1} \end{bmatrix}. \tag{S25}$$

- Test E_k^b with respect to L_j:

$$c_3 = \mathbf{l}_j \times \begin{bmatrix} x_{k1} - x_j \\ y_{k1} - y_j \end{bmatrix}, \quad c_4 = \mathbf{l}_j \times \begin{bmatrix} x_{k2} - x_j \\ y_{k2} - y_j \end{bmatrix}. \tag{S26}$$

4. The intersection condition is:

$$\text{Intersection: } \big(c_1 \cdot c_2 < 0\big) \text{ and } \big(c_3 \cdot c_4 < 0\big). \tag{S27}$$

Series Representation for All Edges

For all edges E_k^b of the rectangle, the intersection condition becomes:

$$P_{\text{line},j}^b = \begin{cases} 1, & \exists k \in \{1,2,3,4\}, \text{ such that } \big(c_1 \cdot c_2 < 0\big) \text{ and } \big(c_3 \cdot c_4 < 0\big), \\ 0, & \text{otherwise.} \end{cases} \tag{S28}$$

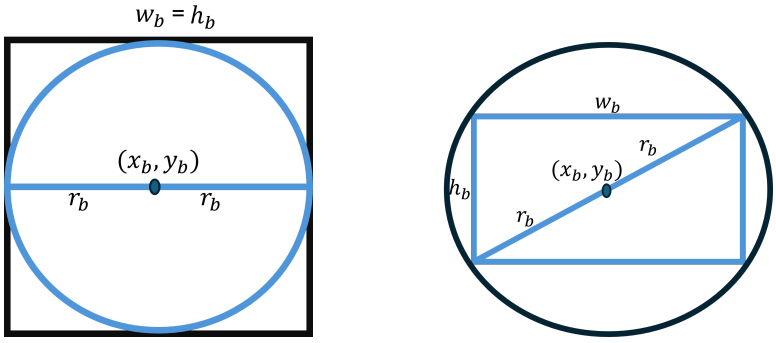
Here, c_1, c_2, c_3, c_4 are computed for each edge E_k^b of the rectangle and line segment L_j.

S2.3 Flexible Conversion and Representation of Obstacles

The proposed fitness function supports flexible conversions between different obstacle types (circular, rectangular, and grid-based obstacles), enabling different representations of the same obstacle.

S2.3.1 Conversion Between Circular and Rectangular Obstacles

A circular obstacle, defined by a center (x_b, y_b) and radius r_b, can be represented as a rectangular obstacle circumscribing the circle, as shown in Fig. S4a. The width w_b and height h_b of this rectangle are given by Eq. (S29). Conversely, a rectangular obstacle, defined by a center (x_b, y_b), width w_b, and height h_b, can be approximated as a circular one circumscribing the rectangle, as shown in Fig. S4b. The radius r_b of this circle is given by Eq.(S30).



(a) Circular to rectangular. (b) Rectangular to circular.

Figure S4: Illustrative figure shows circle and rectangle conversion.

$$w_b = 2r_b, \quad h_b = 2r_b \tag{S29}$$

$$r_b = \frac{1}{2}\sqrt{w_b^2 + h_b^2} \tag{S30}$$

S2.3.2 Circular and Rectangular Obstacles in Grid-Based Representation

The search space, bounded by $[x_{min}, x_{max}]$ and $[y_{min}, y_{max}]$, is discretized into a grid-based environment. Any Cartesian coordinate (x, y) is mapped to grid cell indices (xc, yc) using Eq.(S31). Conversely, the Cartesian coordinates of a grid cell indices are calculated using Eq.(S32), where (x_{res}, y_{res}) is the grid resolution and (x_{og}, y_{og}) is the grid origin, as in Fig. S5. This mapping establishes a seamless bidirectional conversion in either Cartesian or grid-based coordinates.

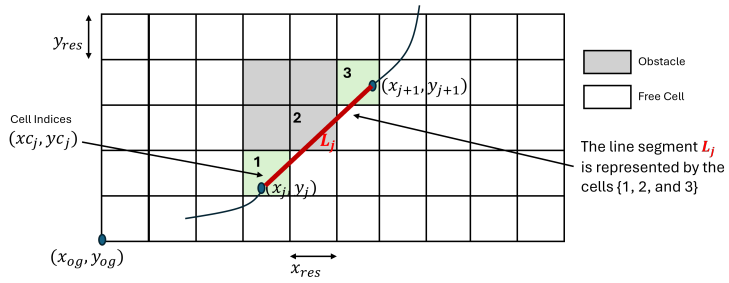


Figure S5: Illustrative figure shows the segment-based cost in grid-based environment.

$$xc = \text{round}\left(\frac{x - x_{og}}{x_{\text{res}}}\right), \quad yc = \text{round}\left(\frac{y - y_{og}}{y_{\text{res}}}\right) \tag{S31}$$

$$x = x_{og} + xc \cdot x_{\text{res}}, \quad y = y_{og} + yc \cdot y_{\text{res}}. \tag{S32}$$

A circular obstacle with center (x_b, y_b) and radius r_b occupies grid cells within the bounding square defined by Eq. (S33) in Cartesian coordinates, where the corresponding cell indices can be obtained from the Eq.(S31). A grid cell (xc, yc) is marked as occupied ($M(xc, yc) = 1$) if its Cartesian coordinates (x, y) satisfies the condition in Eq.(S34), indicating those cells are part of the obstacle. Similarly, a rectangular obstacle with center (x_b, y_b), width w_b, and height h_b occupies grid cells whose Cartesian coordinates (x, y) satisfy the condition in Eq.(S35).

$$x_b - r_b \le x \le x_b + r_b, \quad y_b - r_b \le y \le y_b + r_b. \tag{S33}$$

$$(x - x_b)^2 + (y - y_b)^2 \le r_b^2. \tag{S34}$$

$$x_b - \frac{w_b}{2} \le x \le x_b + \frac{w_b}{2}, \quad y_b - \frac{h_b}{2} \le y \le y_b + \frac{h_b}{2}. \tag{S35}$$

This flexible conversion and discretization framework allows the path-planning platform to generalize for various obstacle types. While convex and irregular shapes are best represented by grid-based obstacles, circular and rectangular shapes remain popular in benchmark testing due to their simplicity. The ability to switch between obstacle representations provides a robust foundation for diverse path-planning applications and a general benchmark testing framework.

S3 Page Test and Convergence of DQSMODE vs MODE

Table S2: Page Test Table for the DQSMODE and the MODE algorithms. The cut points are labelled from C1 to C19 across different point of the run.

Comparison	MODE-DQSMODE	DQSMODE-MODE
L_Statistic	108503.5	80419.5
Asymptotic P-Value	0	1
C1	246.5	751
C2	384.5	611.5
C3	404.5	591.5
C4	381	605.5
C5	398.5	596.5
C6	408.5	590
C7	381.5	613.5
C8	425.5	574
C9	409.5	585
C10	392	594.5
C11	478	518
C12	503	490
C13	533	461
C14	588	403
C15	631	367
C16	654	340
C17	694	300
C18	739	254
C19	797	200

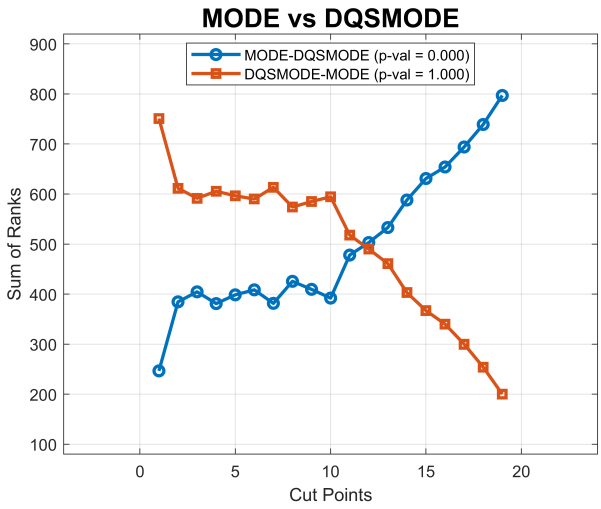


Figure S6: Page Test Convergence trend graph between the DQSMODE and MODE algorithms.

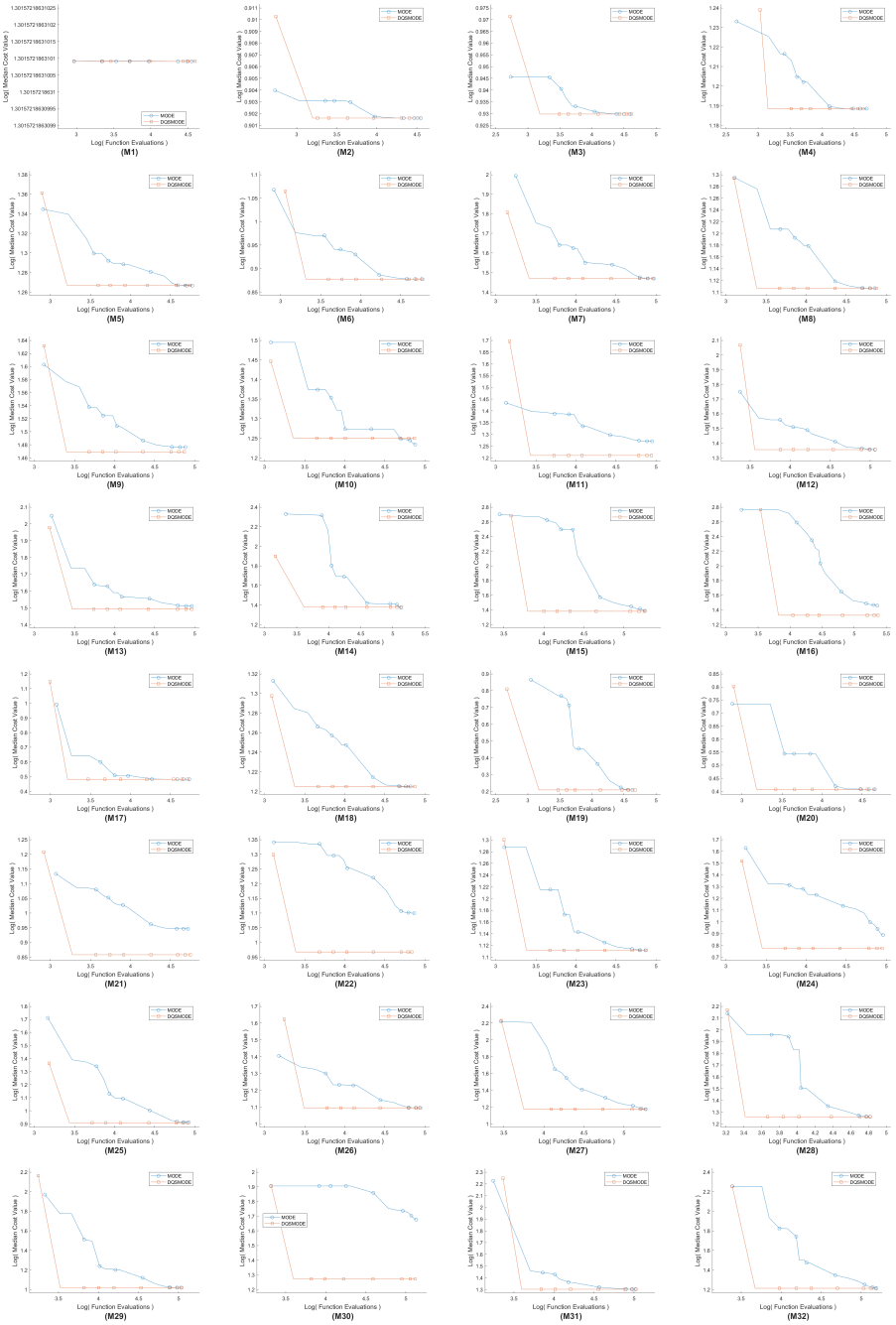


Figure S7: Convergence plots between MODE and DQSMODE for the median cost in 8 runs for all models after Q-learning.

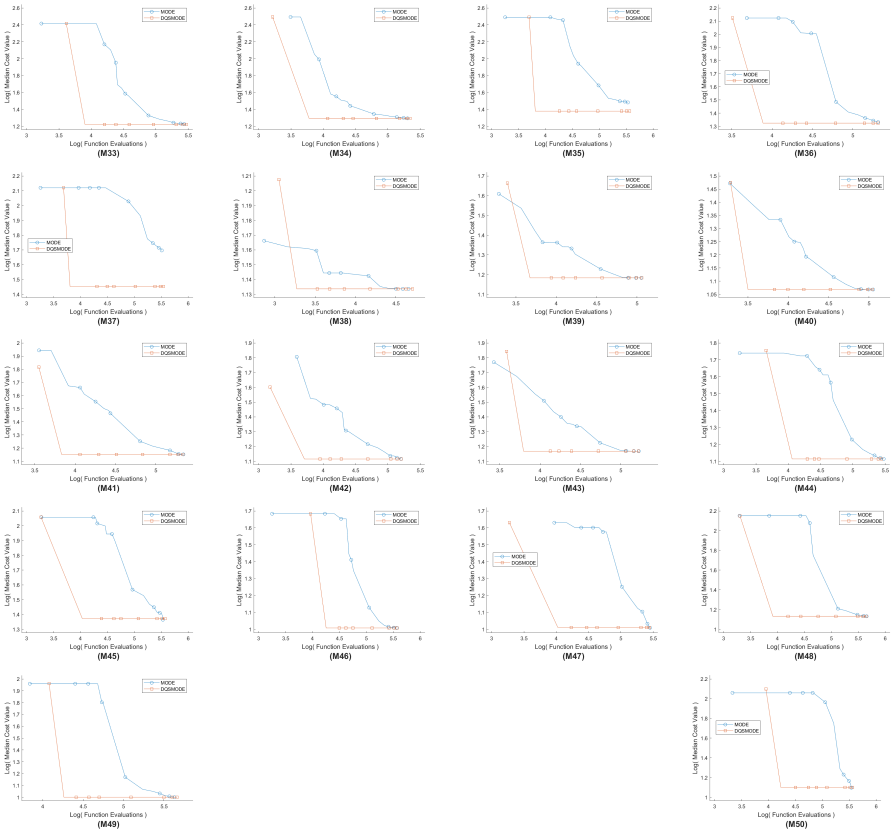


Figure S7 (Cont.): Convergence plots between MODE and DQSMODE for the median cost in 8 runs for all models after Q-learning.

S4 Complete results of the 18 meta-heuristic optimization algorithms

Table S3: Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M1-M4).

M	Alg.	Best	Worst	Median	Mean	SD
M1	DE	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	0.00000000E+00
	FA	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	4.34905393E-11
	TLBO	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	1.64101759E-12
	SA	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	5.77823332E-10
	GA	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	6.74704081E-09
	CMAES	2.00249844E+01	2.06277169E+01	2.00249844E+01	2.00670900E+01	1.35014326E-01
	PSO	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	3.29861184E-15
	BAS	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.99243000E-11
	ABC	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	7.28478093E-14
	WOA	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	5.98786642E-14
	MFO	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	1.61598317E-15
	GWO	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.83482595E-10
	HHO	2.00249844E+01	2.00249847E+01	2.00249844E+01	2.00249844E+01	6.85954734E-08
	CSOA	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	3.36302823E-09
	CSO	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	4.43586645E-14
	IMODEII	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.37866283E-15
	QSMODE	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	3.61344823E-15
	DQSMODE	2.00249844E+01	2.00249844E+01	2.00249844E+01	2.00249844E+01	3.61344823E-15
M2	DE	7.92992566E+00	7.94759817E+00	7.92992566E+00	7.93147348E+00	4.48373684E-03
	FA	7.92999940E+00	7.93157575E+00	7.93065410E+00	7.93068089E+00	3.60719542E-04
	TLBO	7.92992566E+00	7.92992571E+00	7.92992566E+00	7.92992566E+00	1.07835462E-08
	SA	7.93023192E+00	7.94876948E+00	7.93281491E+00	7.93517940E+00	5.59930078E-03
	GA	7.93004332E+00	8.14479930E+00	7.94778062E+00	7.97617225E+00	6.54948881E-02
	CMAES	7.98524431E+00	2.66867573E+02	9.85688997E+00	9.89470141E+01	1.20136846E+02
	PSO	7.92992566E+00	7.94151561E+00	7.92992665E+00	7.93058087E+00	2.23535551E-03
	BAS	7.96544498E+00	8.85148672E+00	8.04632223E+00	8.09051392E+00	1.79091971E-01
	ABC	7.93440817E+00	7.96720496E+00	7.94238869E+00	7.94339357E+00	7.02545155E-03
	WOA	7.92993202E+00	7.93261218E+00	7.93021014E+00	7.93056927E+00	7.54824304E-04
	MFO	7.92992687E+00	7.98927556E+00	7.93408719E+00	7.94101180E+00	1.56944857E-02
	GWO	7.92998350E+00	7.93140387E+00	7.93024938E+00	7.93031260E+00	2.79818615E-04
	HHO	7.93021527E+00	7.98697698E+00	7.94071538E+00	7.94541006E+00	1.43688321E-02
	CSOA	7.93078000E+00	7.93960321E+00	7.93575863E+00	7.93531663E+00	2.51129216E-03
	CSO	7.92992566E+00	7.97437794E+00	7.93065703E+00	7.93566774E+00	1.14290026E-02
	IMODEII	7.92992566E+00	7.92992566E+00	7.92992566E+00	7.92992566E+00	5.30861336E-15
	QSMODE	7.97299489E+00	7.97299489E+00	7.97299489E+00	7.97299489E+00	3.96862898E-15
	DQSMODE	7.97299489E+00	7.97299489E+00	7.97299489E+00	7.97299489E+00	3.42404807E-15
M3	DE	1.03279556E+01	1.08733837E+01	1.03279556E+01	1.04066322E+01	1.55230974E-01
	FA	1.03287750E+01	2.17143066E+02	1.03306726E+01	2.41181662E+01	5.24699858E+01
	TLBO	1.03279556E+01	2.17143066E+02	1.03283631E+01	1.72577466E+01	3.77524324E+01
	SA	1.03301240E+01	2.17143071E+02	1.03570243E+01	9.99567067E+01	1.04228362E+02
	GA	1.03369451E+01	2.17146053E+02	1.05716206E+01	4.50295295E+01	7.82879615E+01
	CMAES	1.07660464E+01	3.13770601E+02	2.31842975E+02	2.15105881E+02	8.55456475E+01
	PSO	2.17143066E+02	2.17143066E+02	2.17143066E+02	2.17143066E+02	1.32786233E-13
	BAS	1.05994044E+01	1.10988635E+01	1.08323163E+01	1.08486589E+01	1.39176075E-01
	ABC	1.03404829E+01	1.05954118E+01	1.04412669E+01	1.04641501E+01	7.61457392E-02
	WOA	1.03280745E+01	2.24304117E+02	1.03310990E+01	4.50382216E+01	7.89438212E+01
	MFO	1.03318414E+01	2.17143066E+02	1.06087723E+01	4.50262289E+01	7.82892188E+01
	GWO	1.03281899E+01	1.03350491E+01	1.03306367E+01	1.03310040E+01	1.86311496E-03
	HHO	1.03606817E+01	2.17143091E+02	1.07461097E+01	1.00065073E+02	1.04132050E+02
	CSOA	1.03460589E+01	2.17143076E+02	1.04278135E+01	7.93140521E+01	9.91259382E+01
	CSO	1.03279557E+01	1.06341862E+01	1.03393588E+01	1.03866930E+01	8.60290792E-02
	IMODEII	1.03279556E+01	2.17143066E+02	1.03279556E+01	5.16909777E+01	8.41402670E+01
	QSMODE	8.50785251E+00	8.50785251E+00	8.50785251E+00	8.50785251E+00	2.55509374E-15
	DQSMODE	8.50785251E+00	8.50785251E+00	8.50785251E+00	8.50785251E+00	3.10963062E-14
M4	DE	1.54528017E+01	1.55055441E+01	1.54528017E+01	1.54565851E+01	1.14692911E-02
	FA	1.54539047E+01	1.55121634E+01	1.54563114E+01	1.54691649E+01	2.15182573E-02
	TLBO	1.53698246E+01	1.54798424E+01	1.54529829E+01	1.54330316E+01	3.79284688E-02
	SA	1.54750529E+01	1.55310180E+01	1.55096645E+01	1.55097804E+01	1.45264482E-02
	GA	1.55146865E+01	1.68258395E+01	1.57381516E+01	1.58335066E+01	3.08358698E-01
	CMAES	1.60269723E+01	4.56397972E+02	2.03883165E+01	1.54925315E+02	1.95664198E+02
	PSO	1.54975778E+01	1.96484255E+01	1.55179129E+01	1.56969776E+01	7.51593489E-01
	BAS	1.57261250E+01	2.04070192E+01	1.64805719E+01	1.69704238E+01	1.29619624E+00
	ABC	1.55066558E+01	1.55844888E+01	1.55321939E+01	1.55333811E+01	1.74311644E-02
	WOA	1.53721850E+01	1.96175239E+01	1.55219103E+01	1.56537074E+01	7.49824615E-01
	MFO	1.54528027E+01	1.55334092E+01	1.54546707E+01	1.54688154E+01	2.47842066E-02
	GWO	1.53709448E+01	1.88069509E+01	1.55094329E+01	1.56039913E+01	6.06104043E-01
	HHO	1.55068672E+01	1.59578232E+01	1.55989023E+01	1.56319074E+01	1.20928846E-01
	CSOA	1.54138526E+01	1.55267012E+01	1.54939627E+01	1.54901345E+01	2.75242146E-02
	CSO	1.54620156E+01	1.57300652E+01	1.55644897E+01	1.55745721E+01	6.44436548E-02
	IMODEII	1.53698105E+01	1.54528017E+01	1.54528017E+01	1.54389698E+01	3.14577330E-02
	QSMODE	1.53845112E+01	1.54375978E+01	1.54375978E+01	1.54199045E+01	2.54498570E-02
	DQSMODE	1.53845112E+01	1.54375978E+01	1.54375978E+01	1.54163632E+01	2.64515381E-02

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M5-M8).

M	Alg.	Best	Worst	Median	Mean	SD
M5	DE	1.76195477E+01	1.91206874E+01	1.84178939E+01	1.86678437E+01	4.4724356 8E-01
	FA	1.84282628E+01	1.91396870E+01	1.84375732E+01	1.86695611E+01	3.37333974E-01
	TLBO	1.78864704E+01	1.91481448E+01	1.84365890E+01	1.86118858E+01	3.30901214E-01
	SA	1.85022922E+01	1.93015878E+01	1.85858254E+01	1.87704475E+01	3.12292034E-01
	GA	1.79081084E+01	2.08355218E+01	1.93432548E+01	1.93338543E+01	6.15217264E-01
	CMAES	1.89128056E+01	7.27346045E+02	2.58317439E+01	1.91692040E+02	2.35811718E+02
	PSO	1.79709177E+01	3.71381755E+02	1.92226432E+01	4.25407672E+01	8.88974140E+01
	BAS	1.98043248E+01	2.51738367E+01	2.19019551E+01	2.19853645E+01	1.59739975E+00
	ABC	1.83865041E+01	1.89489433E+01	1.86554018E+01	1.86702660E+01	1.25560098E-01
	WOA	1.77328106E+01	1.99337638E+01	1.91993502E+01	1.90891847E+01	4.57629046E-01
	MFO	1.84141397E+01	1.91445063E+01	1.84223169E+01	1.86784430E+01	3.47066248E-01
	GWO	1.84293318E+01	1.92197226E+01	1.84495250E+01	1.87200223E+01	3.59022489E-01
	HHO	1.86830328E+01	2.07390238E+01	1.93389481E+01	1.94449872E+01	3.93821733E-01
	CSOA	1.77485621E+01	1.94814577E+01	1.84655928E+01	1.85982617E+01	5.35332605E-01
	CSO	1.84792015E+01	2.01423811E+01	1.92256180E+01	1.91228300E+01	3.87900605E-01
	IMODEII	1.76195477E+01	1.91191831E+01	1.84178939E+01	1.85305058E+01	3.31978468E-01
	QSMODE	1.84679104E+01	1.84813052E+01	1.84679109E+01	1.84703185E+01	4.27004655E-03
	DQSMODE	1.84679104E+01	1.84811890E+01	1.84679105E+01	1.84718350E+01	6.10411394E-03
M6	DE	7.53099018E+00	9.41175383E+00	7.55271517E+00	8.21169879E+00	8.56787835E-01
	FA	7.51558429E+00	9.41655393E+00	7.55183827E+00	7.84017432E+00	6.58466820E-01
	TLBO	7.55060467E+00	8.80944348E+00	7.55276280E+00	7.62321108E+00	2.41638664E-01
	SA	7.56899980E+00	9.58586197E+00	7.60819993E+00	8.23187514E+00	8.83844913E-01
	GA	7.57523456E+00	1.06144859E+01	9.51006194E+00	9.19095899E+00	8.85218776E-01
	CMAES	7.98587166E+00	2.27396040E+02	1.23473195E+01	4.97123973E+01	7.11538117E+01
	PSO	7.55528562E+00	9.99921551E+00	7.61384841E+00	8.15355053E+00	8.60665383E-01
	BAS	7.93495844E+00	1.23692359E+01	1.01361307E+01	9.99107831E+00	1.22963122E+00
	ABC	7.59736828E+00	7.88787825E+00	7.68397796E+00	7.69971224E+00	7.96387244E-02
	WOA	7.53136266E+00	1.00046564E+01	7.56901823E+00	7.65417814E+00	4.44897950E-01
	MFO	7.54768143E+00	9.43991110E+00	9.26303981E+00	8.62111983E+00	8.88515500E-01
	GWO	7.55110867E+00	9.51252352E+00	7.56744807E+00	7.82367732E+00	6.69932216E-01
	HHO	7.56504925E+00	1.09132237E+01	7.71638050E+00	8.15720486E+00	9.17991852E-01
	CSOA	7.54309420E+00	7.58946167E+00	7.57076868E+00	7.56957424E+00	9.89538365E-03
	CSO	7.57106605E+00	1.00303941E+01	7.77847611E+00	8.35121698E+00	9.90187625E-01
	IMODEII	7.54761849E+00	7.54761865E+00	7.54761849E+00	7.54761850E+00	3.10745074E-08
	QSMODE	7.54607262E+00	7.54715472E+00	7.54610455E+00	7.54631931E+00	4.07007746E-04
	DQSMODE	7.54607262E+00	7.54706582E+00	7.54611903E+00	7.54617438E+00	2.42690053E-04
M7	DE	2.94623941E+01	4.41814441E+01	2.94628432E+01	3.03487033E+01	3.00340597E+00
	FA	2.94862602E+01	2.95264835E+01	2.95217768E+01	2.95164409E+01	1.08958372E-02
	TLBO	2.94800446E+01	2.95410129E+01	2.95140962E+01	2.95123155E+01	1.06855785E-02
	SA	2.98369127E+01	3.38586083E+01	3.00959192E+01	3.03067351E+01	9.29615774E-01
	GA	2.96377169E+01	4.10998461E+01	3.15582870E+01	3.23641530E+01	2.85852914E+00
	CMAES	3.66822711E+01	1.50833632E+03	4.10365950E+01	1.92281237E+02	3.49974518E+02
	PSO	3.07534539E+01	6.07957184E+02	6.14414884E+01	2.57523881E+02	2.42101193E+02
	BAS	4.18568283E+01	1.02236366E+03	7.43045184E+01	3.26765895E+02	3.85351477E+02
	ABC	3.00619480E+01	3.23030831E+01	3.09299647E+01	3.08870666E+01	4.87301804E-01
	WOA	2.96715425E+01	3.73940283E+01	3.49405348E+01	3.39648199E+01	2.60849299E+00
	MFO	2.94627222E+01	3.71030028E+01	3.17179771E+01	3.20760588E+01	2.25642461E+00
	GWO	2.95228207E+01	4.07442382E+01	3.02179652E+01	3.15812674E+01	2.82394957E+00
	HHO	3.09722207E+01	3.91682000E+01	3.41157325E+01	3.42436707E+01	1.72223545E+00
	CSOA	2.95459205E+01	3.90971879E+01	3.06950738E+01	3.20276846E+01	2.99269654E+00
	CSO	3.08829310E+01	4.53508272E+01	3.29028207E+01	3.37685374E+01	3.16181947E+00
	IMODEII	2.94623939E+01	2.94937369E+01	2.94627575E+01	2.94651155E+01	5.85257189E-03
	QSMODE	2.94532165E+01	2.94532886E+01	2.94532274E+01	2.94532304E+01	1.46957022E-05
	DQSMODE	2.94532173E+01	2.94532417E+01	2.94532243E+01	2.94532240E+01	5.72449220E-06
M8	DE	1.23033125E+01	1.34317685E+01	1.27860594E+01	1.28400735E+01	2.65454686E-01
	FA	1.23172050E+01	1.34600489E+01	1.28009077E+01	1.28484596E+01	2.21181143E-01
	TLBO	1.23178058E+01	1.33403289E+01	1.26821625E+01	1.26090035E+01	2.51472671E-01
	SA	1.28490649E+01	1.37084662E+01	1.29264631E+01	1.30157151E+01	2.43879211E-01
	GA	1.27510600E+01	1.49031477E+01	1.31751810E+01	1.34395855E+01	6.14617180E-01
	CMAES	1.37699064E+01	3.48639905E+02	1.97498794E+01	4.79542978E+01	8.85583252E+01
	PSO	1.23503274E+01	2.13439606E+02	1.29992000E+01	1.99290506E+01	3.65594946E+01
	BAS	1.37966121E+01	2.33194763E+01	1.79879525E+01	1.81201531E+01	2.09004311E+00
	ABC	1.26164797E+01	1.30006314E+01	1.28886157E+01	1.28786060E+01	8.88596880E-02
	WOA	1.23189025E+01	1.45280170E+01	1.29119697E+01	1.30164618E+01	4.80323579E-01
	MFO	1.23047071E+01	1.54359599E+01	1.27913024E+01	1.31206260E+01	6.94916892E-01
	GWO	1.23144483E+01	1.29060707E+01	1.28211858E+01	1.27450755E+01	2.05876851E-01
	HHO	1.28343739E+01	2.17476278E+01	1.36376377E+01	1.41075732E+01	1.79118150E+00
	CSOA	1.23144180E+01	1.34707257E+01	1.25863056E+01	1.26530758E+01	3.36892010E-01
	CSO	1.24167288E+01	1.46247721E+01	1.32584172E+01	1.34774456E+01	6.49216021E-01
	IMODEII	1.23032581E+01	1.27981731E+01	1.24065704E+01	1.25279360E+01	2.37109875E-01
	QSMODE	1.23026172E+01	1.27986466E+01	1.23128117E+01	1.24997533E+01	2.39353404E-01
	DQSMODE	1.23026173E+01	1.27845164E+01	1.23113907E+01	1.25127286E+01	2.41539091E-01

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M9-M12).

M	Alg.	Best	Worst	Median	Mean	SD
M9	DE	2.95895437E+01	3.03658885E+01	3.03364848E+01	3.01491785E+01	2.34200734E-01
	FA	2.94983492E+01	3.04367217E+01	2.99582355E+01	3.00611843E+01	2.27516968E-01
	TLBO	2.92622033E+01	3.04321960E+01	2.99756317E+01	3.00409754E+01	2.96634121E-01
	SA	3.00754485E+01	3.05886343E+01	3.01820203E+01	3.02598834E+01	1.70924480E-01
	GA	3.00733255E+01	3.23105201E+01	3.07204002E+01	3.07808595E+01	4.39087727E-01
	CMAES	3.13164052E+01	6.94524677E+02	3.68955310E+01	1.26966624E+02	2.07866684E+02
	PSO	3.01101321E+01	3.73037709E+01	3.06611372E+01	3.09834219E+01	1.28519763E+00
	BAS	3.12807026E+01	5.34131389E+01	4.12248752E+01	4.16028165E+01	5.87443830E+00
	ABC	3.00887072E+01	3.04459936E+01	3.02933559E+01	3.02876220E+01	9.11214350E-02
	WOA	3.00670019E+01	3.20544625E+01	3.04484872E+01	3.05851874E+01	4.05933639E-01
	MFO	2.99156696E+01	3.35093459E+01	2.99385408E+01	3.04097322E+01	8.57877793E-01
	GWO	3.01098555E+01	3.08941804E+01	3.03256603E+01	3.03797897E+01	2.29018190E-01
	HHO	3.02677535E+01	3.56180452E+01	3.13664865E+01	3.16596284E+01	1.30344805E+00
	CSOA	2.89465539E+01	3.05228258E+01	3.01972504E+01	3.00707921E+01	3.92267790E-01
	CSO	3.01200486E+01	3.21065262E+01	3.06524287E+01	3.08119192E+01	5.02919409E-01
	IMODEII	2.95807643E+01	3.03357246E+01	2.99151927E+01	2.99774881E+01	2.00416894E-01
	QSMODE	2.95808490E+01	2.99467056E+01	2.99467031E+01	2.99223141E+01	9.28167658E-02
	DQSMODE	2.99467031E+01	2.99472037E+01	2.99467041E+01	2.99467876E+01	1.89274055E-04
M10	DE	1.70742927E+01	2.05212807E+01	1.77967102E+01	1.82331795E+01	1.37814875E+00
	FA	1.70935857E+01	2.05921134E+01	1.78157338E+01	1.82447553E+01	1.26838098E+00
	TLBO	1.70983415E+01	2.05679617E+01	1.78100166E+01	1.81255967E+01	1.26425420E+00
	SA	1.74212955E+01	2.08490327E+01	2.03555354E+01	1.95046045E+01	1.28406804E+00
	GA	1.72336364E+01	2.16952496E+01	1.96531211E+01	1.97671821E+01	1.44973211E+00
	CMAES	2.40486158E+01	7.38464605E+02	3.32602020E+02	2.65367054E+02	2.31968043E+02
	PSO	1.72161403E+01	5.65439838E+02	1.60448384E+02	1.71223007E+02	1.61617953E+02
	BAS	2.14840717E+01	5.21008960E+02	2.52925517E+01	9.27748005E+01	1.54965229E+02
	ABC	1.74584007E+01	1.89639945E+01	1.81962417E+01	1.81613076E+01	4.36702906E-01
	WOA	1.79219680E+01	2.98700309E+02	2.09352470E+01	5.74722548E+01	9.59185845E+01
	MFO	1.78032201E+01	2.61405651E+01	2.05214960E+01	2.08221096E+01	2.11938984E+00
	GWO	1.71014379E+01	2.07622840E+01	1.92607518E+01	1.89828361E+01	1.66276786E+00
	HHO	2.03841671E+01	3.15160656E+02	2.21114335E+01	6.95723801E+01	1.08159715E+02
	CSOA	1.71274777E+01	2.17398029E+01	1.72208331E+01	1.77441832E+01	1.08298814E+00
	CSO	1.72062418E+01	2.27451960E+01	2.08909230E+01	2.04888661E+01	1.46330595E+00
	IMODEII	1.70742928E+01	1.81462605E+01	1.77966811E+01	1.74733251E+01	3.81371296E-01
	QSMODE	1.70677242E+01	1.81322835E+01	1.70678606E+01	1.72581475E+01	3.58030831E-01
	DQSMODE	1.70677310E+01	1.77825215E+01	1.70678690E+01	1.73532810E+01	3.55627397E-01
M11	DE	1.62159286E+01	2.04089369E+01	1.86602638E+01	1.85458742E+01	9.89594817E-01
	FA	1.86739436E+01	2.04724849E+01	1.87024989E+01	1.90456183E+01	7.08912255E-01
	TLBO	1.62255446E+01	1.90911879E+01	1.63564792E+01	1.69895386E+01	1.01513640E+00
	SA	1.80214604E+01	2.08502074E+01	1.89687755E+01	1.91742581E+01	6.68423596E-01
	GA	1.67840068E+01	2.24699730E+01	1.90895777E+01	1.92466707E+01	1.23353571E+00
	CMAES	2.19624986E+01	3.86458742E+02	1.83478198E+02	1.81947175E+02	1.57672253E+02
	PSO	1.63849806E+01	3.12350999E+02	1.34537601E+02	1.40343769E+02	1.24382374E+02
	BAS	2.13505412E+01	7.51282777E+02	3.99107699E+01	1.39092839E+02	1.99406383E+02
	ABC	1.67923082E+01	1.90267580E+01	1.76053759E+01	1.76725667E+01	7.25161236E-01
	WOA	1.64641555E+01	2.45292854E+02	1.99968147E+01	3.48343719E+01	5.72069738E+01
	MFO	1.62178907E+01	2.57838110E+01	1.99406321E+01	2.04950930E+01	2.45184148E+00
	GWO	1.62253629E+01	2.04759242E+01	1.74415139E+01	1.74652690E+01	1.27945643E+00
	HHO	1.69806128E+01	2.64002896E+02	2.03287709E+01	2.86274227E+01	4.44897750E+01
	CSOA	1.62384151E+01	2.45500251E+02	1.76394967E+01	4.07149070E+01	6.93505263E+01
	CSO	1.66449497E+01	2.31213531E+01	2.04797921E+01	2.03583844E+01	1.58765622E+00
	IMODEII	1.62158065E+01	1.74571143E+01	1.62173317E+01	1.63363012E+01	3.61165095E-01
	QSMODE	1.62153791E+01	1.86596272E+01	1.62155331E+01	1.63786408E+01	6.19981292E-01
	DQSMODE	1.62152569E+01	1.62161285E+01	1.62155090E+01	1.62155752E+01	1.98330461E-04
M12	DE	2.27146964E+01	2.69286818E+01	2.61354477E+01	2.54899937E+01	1.38960467E+00
	FA	2.34025047E+01	2.69685992E+01	2.61682614E+01	2.58507030E+01	1.11295752E+00
	TLBO	2.28115169E+01	2.69688952E+01	2.35514950E+01	2.40619810E+01	9.83558941E-01
	SA	2.40755366E+01	2.75404960E+01	2.64524815E+01	2.62129685E+01	1.05999802E+00
	GA	2.28914407E+01	3.16508907E+01	2.54698966E+01	2.60035628E+01	2.25288019E+00
	CMAES	3.05937894E+01	7.36477590E+02	3.89203419E+01	1.66520151E+02	2.22643371E+02
	PSO	2.30570539E+01	4.34597422E+02	2.50920424E+01	1.10384389E+02	1.44861808E+02
	BAS	4.03156676E+01	1.00903641E+03	9.00151239E+01	3.64226413E+02	3.62384303E+02
	ABC	2.41386023E+01	2.75987227E+01	2.61791698E+01	2.60093071E+01	9.88734136E-01
	WOA	2.37400282E+01	5.88333164E+02	2.72585473E+01	1.01454917E+02	1.46301776E+02
	MFO	2.35393397E+01	3.36939210E+01	2.91716382E+01	2.96004039E+01	2.37505679E+00
	GWO	2.27190792E+01	3.04132840E+01	2.38992158E+01	2.42405906E+01	1.48615987E+00
	HHO	2.46248753E+01	3.57874825E+01	2.81328439E+01	2.85441098E+01	2.29440710E+00
	CSOA	2.27181974E+01	3.11288200E+01	2.41413926E+01	2.47293266E+01	1.82762368E+00
	CSO	2.35701801E+01	3.47247168E+02	2.84804108E+01	3.89813243E+01	5.82650173E+01
	IMODEII	2.27145179E+01	2.40718862E+01	2.27146830E+01	2.28456410E+01	3.49401035E-01
	QSMODE	2.27145482E+01	2.27149333E+01	2.27146959E+01	2.27147084E+01	1.05005907E-04
	DQSMODE	2.27145620E+01	2.40673136E+01	2.27146685E+01	2.27597789E+01	2.46953885E-01

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M13-M16).

M	Alg.	Best	Worst	Median	Mean	SD
M13	DE	2.96120451E+01	3.55351847E+01	3.24301626E+01	3.26540344E+01	9.29067873E-01
	FA	3.09773607E+01	3.27899597E+01	3.24707071E+01	3.23887409E+01	4.79281498E-01
	TLBO	2.96759544E+01	3.27945197E+01	3.24542242E+01	3.18090702E+01	1.03587377E+00
	SA	3.05908248E+01	3.35129165E+01	3.29112742E+01	3.27553911E+01	6.83509374E-01
	GA	3.17148441E+01	3.85980382E+01	3.33739154E+01	3.34755974E+01	1.32740938E+00
	CMAES	3.80885385E+01	1.48856079E+03	5.46742962E+02	5.68930118E+02	5.18207258E+02
	PSO	3.25146884E+01	8.69464496E+02	4.52827494E+02	3.75007560E+02	2.73304147E+02
	BAS	4.97435767E+01	1.64074696E+03	8.20830571E+01	5.22645783E+02	5.34869647E+02
	ABC	3.16778827E+01	3.40358005E+01	3.30084018E+01	3.29132628E+01	5.54766017E-01
	WOA	2.98421847E+01	1.24046732E+03	3.30479676E+01	7.37988439E+01	2.20356367E+02
	MFO	3.14970319E+01	3.92036913E+01	3.74370151E+01	3.62351822E+01	2.40022915E+00
	GWO	2.96844697E+01	3.64333918E+01	3.24950783E+01	3.20748368E+01	1.66018358E+00
	HHO	3.28128336E+01	4.69553440E+02	3.40267824E+01	4.94034592E+01	7.94493966E+01
	CSOA	2.97464211E+01	4.40323373E+02	3.24838231E+01	4.63572188E+01	7.44339102E+01
	CSO	3.15589286E+01	3.95743846E+01	3.43707639E+01	3.46737525E+01	1.59454629E+00
	IMODEII	2.96119989E+01	3.24277177E+01	2.96228798E+01	3.02147056E+01	8.73276243E-01
	QSMODE	2.96062679E+01	3.24272407E+01	2.96074183E+01	2.98489126E+01	7.44824956E-01
	DQSMODE	2.96062788E+01	3.24272806E+01	2.96080162E+01	3.05031719E+01	1.30425433E+00
M14	DE	2.34935533E+01	3.62215406E+01	2.63411606E+01	2.72528519E+01	3.21934529E+00
	FA	2.55726419E+01	2.64054627E+01	2.63753994E+01	2.63284071E+01	2.05675286E-01
	TLBO	2.32052528E+01	3.22666765E+01	2.54062231E+01	2.52816553E+01	1.82062390E+00
	SA	2.47118376E+01	2.74774895E+01	2.72320459E+01	2.71559994E+01	4.80661617E-01
	GA	2.32293712E+01	3.25821340E+01	2.73762072E+01	2.77275751E+01	1.94553630E+00
	CMAES	3.03527324E+01	7.18806679E+02	4.00749268E+01	1.28250399E+02	1.91326372E+02
	PSO	2.36000209E+01	8.31453280E+02	3.41303170E+01	1.36218296E+02	2.00640760E+02
	BAS	4.32307862E+01	1.86470933E+03	7.72067959E+02	7.72835474E+02	5.46595422E+02
	ABC	2.54720954E+01	3.01656130E+01	2.81778377E+01	2.81804146E+01	8.79217253E-01
	WOA	2.32548984E+01	2.71544811E+01	2.35761460E+01	2.45703611E+01	1.58926941E+00
	MFO	2.74956248E+01	3.46094787E+01	3.16859704E+01	3.14576289E+01	1.54325852E+00
	GWO	2.30707255E+01	3.32024544E+01	2.56698008E+01	2.58993134E+01	2.71503566E+00
	HHO	2.47400605E+01	3.14991903E+01	2.86304124E+01	2.84715595E+01	1.91988328E+00
	CSOA	2.30781055E+01	4.40036573E+01	2.57408899E+01	2.75153650E+01	5.22958864E+00
	CSO	2.51262669E+01	4.51947110E+01	3.17196680E+01	3.28987041E+01	5.02954724E+00
	IMODEII	2.30453063E+01	2.30537740E+01	2.30468062E+01	2.30473486E+01	1.89157239E-03
	QSMODE	2.30439429E+01	2.30496933E+01	2.30445602E+01	2.30450053E+01	1.18734004E-03
	DQSMODE	2.30440543E+01	2.34940318E+01	2.30448378E+01	2.31045877E+01	1.55364157E-01
M15	DE	2.93952511E+01	4.19391974E+01	3.03503490E+01	3.21135907E+01	3.36151456E+00
	FA	2.58383934E+01	5.25865809E+01	2.94307106E+01	2.96780411E+01	4.68774397E+00
	TLBO	2.71509343E+01	4.19391974E+01	3.18070254E+01	3.25288317E+01	3.95922876E+00
	SA	2.86153940E+01	5.73464586E+01	3.08274207E+01	3.21371196E+01	5.86059965E+00
	GA	2.43166026E+01	3.79216043E+02	2.78803365E+01	4.35719945E+01	6.40699656E+01
	CMAES	4.46839999E+01	6.68876301E+02	4.13685515E+02	4.23011499E+02	1.67680117E+02
	PSO	2.97250936E+01	1.75610755E+03	7.44616447E+02	7.82212712E+02	3.90006565E+02
	BAS	1.22353704E+03	4.04604033E+03	2.89196787E+03	2.80919685E+03	7.49217539E+02
	ABC	2.93328605E+01	3.76959407E+01	3.38966933E+01	3.36592848E+01	2.23989183E+00
	WOA	3.02368761E+01	4.51297590E+02	3.40663893E+01	1.98886291E+02	2.00644747E+02
	MFO	3.21998596E+01	4.35111461E+01	3.47860607E+01	3.62793065E+01	2.72751940E+00
	GWO	2.42461916E+01	5.58357707E+01	2.79227323E+01	3.00657800E+01	5.86839682E+00
	HHO	3.12089885E+01	4.48612732E+01	3.24877795E+01	3.30286284E+01	2.37216959E+00
	CSOA	2.38389511E+01	6.96493401E+02	1.41964614E+02	2.05600565E+02	2.04863841E+02
	CSO	2.86658024E+01	7.14592182E+02	4.68714495E+01	1.93231960E+02	2.02790464E+02
	IMODEII	2.37334804E+01	2.41853678E+01	2.37364604E+01	2.38846212E+01	2.14881022E-01
	QSMODE	2.37348507E+01	2.41773642E+01	2.41750769E+01	2.41312157E+01	1.34288955E-01
	DQSMODE	2.37344248E+01	2.41757807E+01	2.41746560E+01	2.39987897E+01	2.19322027E-01
M16	DE	2.67671524E+01	3.92340509E+01	2.80031292E+01	2.96931961E+01	3.49013877E+00
	FA	2.15141795E+01	4.75075714E+01	2.70520319E+01	2.83271181E+01	4.90396437E+00
	TLBO	2.16606709E+01	5.22623781E+01	3.35911575E+01	3.38071808E+01	5.93639269E+00
	SA	2.83293146E+01	2.95053293E+01	2.89659481E+01	2.89386226E+01	2.67987008E-01
	GA	2.20710618E+01	2.32769246E+02	2.82477750E+01	3.88643735E+01	3.78567338E+01
	CMAES	3.01480047E+02	5.54058561E+02	4.78218134E+02	4.71266847E+02	9.26981848E+01
	PSO	2.80915417E+01	2.25917723E+03	8.82678585E+02	1.01857201E+03	5.60765913E+02
	BAS	1.86419734E+03	7.26224280E+03	4.66749292E+03	4.50798399E+03	1.45978457E+03
	ABC	2.74691284E+01	4.27484411E+01	3.25201883E+01	3.24829703E+01	4.03176581E+00
	WOA	2.45080007E+01	3.37375591E+02	2.58305852E+02	2.02193264E+02	1.44922853E+02
	MFO	3.23691020E+01	4.14318656E+01	3.80543194E+01	3.68882324E+01	3.23879593E+00
	GWO	2.16837603E+01	5.58198001E+01	3.18889531E+01	3.17764019E+01	7.29857638E+00
	HHO	2.59476081E+01	4.58806511E+02	3.17751306E+01	1.32860585E+02	1.60983956E+02
	CSOA	2.37197550E+01	6.50895232E+02	2.27166173E+02	2.16429585E+02	1.85312032E+02
	CSO	2.69946122E+01	1.81652046E+03	3.77918463E+02	4.56133946E+02	4.11720412E+02
	IMODEII	2.11077873E+01	1.78882301E+02	1.78858607E+02	1.21025148E+02	7.73148494E+01
	QSMODE	2.11087948E+01	6.22216069E+01	2.11123980E+01	3.12442280E+01	1.72378612E+01
	DQSMODE	2.11089786E+01	6.17413742E+01	2.12313009E+01	2.42667001E+01	7.50583392E+00

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M17-M20).

M	Alg.	Best	Worst	Median	Mean	SD
M17	DE	3.03738876E+00	3.03751576E+00	3.03738876E+00	3.03739299E+00	2.31869328E-05
	FA	3.03783592E+00	3.03912867E+00	3.03837628E+00	3.03836629E+00	3.23419511E-04
	TLBO	3.03738876E+00	3.03738881E+00	3.03738876E+00	3.03738876E+00	1.39030744E-08
	SA	3.05129476E+00	3.14382187E+00	3.09327853E+00	3.09223971E+00	2.67596140E-02
	GA	3.11934596E+00	2.30790232E+02	5.86800966E+00	2.03005749E+01	4.41270461E+01
	CMAES	4.75678655E+00	2.90946272E+02	1.45640755E+01	5.98922757E+01	8.20303620E+01
	PSO	3.03738879E+00	6.43183167E+01	3.08477164E+00	1.51947706E+01	2.37872002E+01
	BAS	3.98474531E+00	1.71391304E+01	1.11108574E+01	1.04837086E+01	3.45089729E+00
	ABC	3.03890035E+00	3.06079712E+00	3.04442147E+00	3.04476941E+00	4.83553784E-03
	WOA	3.03747601E+00	3.88638736E+00	3.03819812E+00	3.06685774E+00	1.54789365E-01
	MFO	3.03738876E+00	1.09612331E+01	3.03738899E+00	4.00322428E+00	2.40660487E+00
	GWO	3.03742406E+00	3.23341796E+00	3.03747228E+00	3.04431164E+00	3.57261868E-02
	HHO	3.04059185E+00	4.04720588E+00	3.53933254E+00	3.57095444E+00	3.58750651E-01
	CSOA	3.03890239E+00	6.13532895E+01	3.09394618E+00	5.06971330E+00	1.06307141E+01
	CSO	3.04251367E+00	3.24957108E+00	3.07898293E+00	3.09835639E+00	5.46646201E-02
	IMODEII	3.03738876E+00	3.03738876E+00	3.03738876E+00	3.03738876E+00	3.29861184E-16
	QSMODE	3.03738876E+00	3.03738876E+00	3.03738876E+00	3.03738876E+00	1.68127857E-09
	DQSMODE	3.03738876E+00	3.03738876E+00	3.03738876E+00	3.03738876E+00	3.31486940E-10
M18	DE	1.44238914E+01	1.75075247E+01	1.44238914E+01	1.47270186E+01	9.25003431E-01
	FA	1.44239239E+01	1.77293045E+01	1.44240269E+01	1.49388433E+01	1.09842775E+00
	TLBO	1.44238914E+01	1.59754429E+01	1.44249209E+01	1.48008948E+01	6.21038800E-01
	SA	1.44372103E+01	1.78697494E+01	1.44577093E+01	1.51819196E+01	1.10930503E+00
	GA	1.44265111E+01	2.18440059E+01	1.54726717E+01	1.61649026E+01	1.96315573E+00
	CMAES	1.63341413E+01	3.00507771E+02	1.88997363E+01	2.86593208E+01	5.14097602E+01
	PSO	1.44239480E+01	2.56944076E+02	1.44427299E+01	2.34171354E+01	4.41634772E+01
	BAS	1.53677538E+01	3.30018391E+02	2.38603538E+01	3.49584978E+01	5.60015810E+01
	ABC	1.44275403E+01	1.45240037E+01	1.44430750E+01	1.44487355E+01	2.00163570E-02
	WOA	1.44241305E+01	1.77936129E+01	1.44437333E+01	1.54253194E+01	1.22671224E+00
	MFO	1.44238914E+01	2.40935125E+01	1.62019992E+01	1.71905717E+01	3.14308459E+00
	GWO	1.44239285E+01	1.72524811E+01	1.44327149E+01	1.51662755E+01	9.57489678E-01
	HHO	1.44574135E+01	1.79579629E+01	1.73876604E+01	1.67262968E+01	1.27006828E+00
	CSOA	1.44246243E+01	1.44339248E+01	1.44257537E+01	1.44266214E+01	2.31416407E-03
	CSO	1.44279687E+01	1.97922155E+01	1.63513022E+01	1.62184117E+01	1.24727741E+00
	IMODEII	1.44238914E+01	1.59731439E+01	1.59731439E+01	1.54567264E+01	7.42809749E-01
	QSMODE	1.44238914E+01	1.60371317E+01	1.60262421E+01	1.57578996E+01	6.06825966E-01
	DQSMODE	1.44238990E+01	1.60318740E+01	1.60118766E+01	1.55927123E+01	7.16679899E-01
M19	DE	1.56619038E+00	3.45941171E+00	3.45941171E+00	2.80496271E+00	8.97927286E-01
	FA	1.56935353E+00	3.47561133E+00	3.46659860E+00	2.71071227E+00	9.44986714E-01
	TLBO	1.56619038E+00	1.56626883E+00	1.56619038E+00	1.56619438E+00	1.47509416E-05
	SA	1.62229948E+00	3.65928227E+00	3.56784131E+00	2.90938110E+00	9.17594821E-01
	GA	2.12952689E+00	6.14527299E+00	3.83885074E+00	3.86182286E+00	7.80701740E-01
	CMAES	2.17015021E+00	1.46672830E+02	7.58971803E+00	2.06985173E+01	3.35391822E+01
	PSO	1.58300442E+00	2.60000000E+01	3.49294557E+00	4.60566510E+00	5.92791538E+00
	BAS	2.30416629E+00	6.26016619E+00	4.59624319E+00	4.34640964E+00	1.12993733E+00
	ABC	1.63995434E+00	2.03836473E+00	1.75292426E+00	1.75638057E+00	9.09953289E-02
	WOA	1.68929133E+00	5.40302675E+00	2.79977500E+00	3.03378340E+00	1.08045383E+00
	MFO	1.56619123E+00	4.23458573E+00	3.45941843E+00	3.12916736E+00	8.34854646E-01
	GWO	1.56760988E+00	4.36787076E+00	1.56849376E+00	1.66192799E+00	5.11071586E-01
	HHO	1.61481057E+00	4.64158476E+00	2.92222208E+00	3.15191320E+00	9.59527428E-01
	CSOA	1.58118360E+00	3.56455137E+00	1.63499456E+00	1.81296456E+00	4.85030842E-01
	CSO	1.63159594E+00	4.49889331E+00	2.45711832E+00	2.85226386E+00	1.10966501E+00
	IMODEII	1.56619038E+00	1.56619038E+00	1.56619038E+00	1.56619038E+00	4.45999280E-16
	QSMODE	1.61733028E+00	1.61757009E+00	1.61734135E+00	1.61737372E+00	7.70942616E-05
	DQSMODE	1.61734126E+00	1.61756366E+00	1.61734138E+00	1.61734934E+00	4.04860498E-05
M20	DE	2.55730525E+00	4.86432845E+00	2.63432377E+00	3.63985498E+00	1.16512776E+00
	FA	2.55731524E+00	4.87753345E+00	2.55743663E+00	3.32924428E+00	1.11020831E+00
	TLBO	2.55730525E+00	4.86432845E+00	2.55730551E+00	2.71118955E+00	5.85288086E-01
	SA	2.55785594E+00	5.04616983E+00	2.56017446E+00	3.35539638E+00	1.14650057E+00
	GA	2.58543560E+00	8.49558196E+00	5.33784188E+00	5.45251127E+00	1.16179310E+00
	CMAES	2.56406978E+00	1.36452474E+02	6.14939909E+00	1.72233600E+01	3.66932343E+01
	PSO	2.55730538E+00	5.38276073E+00	2.56404189E+00	3.37478722E+00	1.17400678E+00
	BAS	2.57313553E+00	9.56547713E+00	3.70355271E+00	4.42254233E+00	2.01041171E+00
	ABC	2.55764389E+00	2.56262198E+00	2.55927721E+00	2.55964276E+00	1.16457776E-03
	WOA	2.55797630E+00	6.62503393E+00	4.78934075E+00	4.12499300E+00	1.44889764E+00
	MFO	2.59642896E+00	5.78957902E+00	4.86494530E+00	4.62273667E+00	8.62934573E-01
	GWO	2.55733900E+00	5.34131659E+00	4.96843531E+00	4.26355379E+00	1.23406136E+00
	HHO	2.80196978E+00	9.83187491E+00	5.52435734E+00	5.57874013E+00	1.48294589E+00
	CSOA	2.55740235E+00	2.55839591E+00	2.55781106E+00	2.55782348E+00	2.65026138E-04
	CSO	2.55730756E+00	5.52919067E+00	5.08450863E+00	4.24747610E+00	1.27734646E+00
	IMODEII	2.55730525E+00	4.86432845E+00	2.55730525E+00	2.94180911E+00	8.74474889E-01
	QSMODE	2.55757061E+00	5.03608074E+00	2.55757061E+00	2.82722178E+00	7.58119856E-01
	DQSMODE	2.55757061E+00	5.03538076E+00	2.55757064E+00	2.88792416E+00	8.56637395E-01

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M21-M24).

M	Alg.	Best	Worst	Median	Mean	SD
M21	DE	8.76916894E+00	8.79216569E+00	8.76916894E+00	8.76993550E+00	4.19861356E-03
	FA	5.53779596E+00	8.78246941E+00	8.77749685E+00	8.53714405E+00	6.95907353E-01
	TLBO	5.54172347E+00	8.76930642E+00	8.76916894E+00	8.26692113E+00	1.01187446E+00
	SA	7.40476629E+00	9.07835024E+00	8.98601591E+00	8.80546058E+00	4.45637109E-01
	GA	5.73288783E+00	1.54611763E+02	9.34229800E+00	1.90115871E+01	3.61702315E+01
	CMAES	8.93709948E+00	3.13973038E+02	2.35937225E+01	9.43356442E+01	9.86404004E+01
	PSO	5.53547117E+00	1.68883866E+02	6.03737222E+01	6.35005418E+01	5.70586171E+01
	BAS	9.08559921E+00	1.25069563E+02	1.40306136E+01	1.79840122E+01	2.04073964E+01
	ABC	5.89644775E+00	8.09852594E+00	6.44322207E+00	6.58750970E+00	5.46250302E-01
	WOA	6.82289941E+00	1.55481345E+02	9.95052700E+00	1.94878047E+01	3.67766172E+01
	MFO	7.50565684E+00	1.41313358E+01	9.02007992E+00	9.23566686E+00	1.17509802E+00
	GWO	6.01055756E+00	1.70389848E+01	8.77185683E+00	9.08627842E+00	2.24952998E+00
	HHO	8.87021699E+00	1.63800138E+02	9.74766923E+00	1.85609017E+01	3.31056915E+01
	CSOA	5.54156140E+00	1.11374052E+02	8.81569931E+00	2.90380538E+01	4.19179600E+01
	CSO	6.00090837E+00	1.10990869E+01	9.48502042E+00	9.33807621E+00	1.28230503E+00
	IMODEII	5.52953261E+00	1.11302927E+02	5.52953261E+00	1.01000119E+01	1.91730421E+01
	QSMODE	5.57677216E+00	8.84719284E+00	8.83625389E+00	7.84389211E+00	1.43729699E+00
	DQSMODE	5.57677224E+00	8.84519595E+00	5.57679019E+00	6.12164400E+00	1.23880566E+00
M22	DE	9.09435880E+00	1.23940487E+01	1.23940487E+01	1.17341107E+01	1.34243958E+00
	FA	9.12111700E+00	1.33915577E+01	1.24145248E+01	1.17660798E+01	1.46124140E+00
	TLBO	9.44543582E+00	1.25489005E+01	1.23940487E+01	1.20002155E+01	9.39860142E-01
	SA	1.01663394E+01	6.92838608E+01	1.31826995E+01	1.41797480E+01	1.05032623E+01
	GA	8.51516064E+00	1.24428488E+02	1.51275518E+01	4.54042651E+01	4.46071203E+01
	CMAES	1.41392152E+01	3.15009108E+02	7.22401651E+01	1.19272223E+02	1.00262714E+02
	PSO	1.35661199E+01	1.50478978E+02	7.36442250E+01	8.01656460E+01	2.93095416E+01
	BAS	1.55750708E+01	2.84232940E+02	2.75082485E+01	8.21357616E+01	9.36431630E+01
	ABC	1.11113838E+01	1.59652443E+01	1.39697912E+01	1.34625840E+01	1.38611119E+00
	WOA	9.87183721E+00	1.81407438E+02	6.14432088E+01	5.37312361E+01	3.63218606E+01
	MFO	1.08936140E+01	1.73459062E+01	1.37993088E+01	1.42844337E+01	1.52168214E+00
	GWO	8.34158819E+00	1.56733670E+02	1.24856288E+01	2.95371487E+01	3.21465175E+01
	HHO	1.32325540E+01	1.89218697E+02	7.29274973E+01	6.56972495E+01	4.21908562E+01
	CSOA	9.96815016E+00	6.30864831E+01	1.44694772E+01	3.23680423E+01	2.37949554E+01
	CSO	1.04943298E+01	1.87680445E+01	1.60161868E+01	1.54525529E+01	2.30485399E+00
	IMODEII	9.09435880E+00	5.85555685E+01	1.23940487E+01	2.53275851E+01	2.07550350E+01
	QSMODE	9.23034103E+00	1.26248046E+01	9.27250677E+00	1.02478134E+01	1.52230927E+00
	DQSMODE	9.26836537E+00	1.27967913E+01	1.08914216E+01	1.09700813E+01	1.73184695E+00
M23	DE	1.29181234E+01	1.54300716E+01	1.29181234E+01	1.32499047E+01	8.60358578E-01
	FA	1.29193683E+01	1.53999620E+01	1.29210801E+01	1.33336940E+01	9.38816868E-01
	TLBO	1.19321891E+01	1.53930203E+01	1.29181234E+01	1.29501548E+01	7.96342068E-01
	SA	1.29261510E+01	1.57467218E+01	1.30986335E+01	1.35931936E+01	1.04716601E+00
	GA	1.29833554E+01	1.67102032E+01	1.37168391E+01	1.45859579E+01	1.36112775E+00
	CMAES	1.33380231E+01	6.45315952E+02	2.23288575E+01	1.06830710E+02	1.51840230E+02
	PSO	1.19568040E+01	2.13776168E+02	1.57935718E+01	1.04668260E+02	9.83688834E+01
	BAS	1.46330426E+01	2.61850035E+01	1.94420910E+01	2.02761899E+01	3.41209109E+00
	ABC	1.26041189E+01	1.36183330E+01	1.32333574E+01	1.32716215E+01	1.85480071E-01
	WOA	1.19326817E+01	2.11658878E+02	1.55057812E+01	2.13125262E+01	3.59744352E+01
	MFO	1.29181234E+01	1.79007433E+01	1.50510941E+01	1.47812729E+01	1.90459834E+00
	GWO	1.22242662E+01	1.56269464E+01	1.30046307E+01	1.39675024E+01	1.28617073E+00
	HHO	1.28525418E+01	2.02821810E+01	1.51865857E+01	1.53421612E+01	1.73378763E+00
	CSOA	1.18031506E+01	1.55858668E+01	1.27178811E+01	1.28435250E+01	1.11261891E+00
	CSO	1.30649918E+01	1.69595762E+01	1.34102990E+01	1.41344306E+01	1.37336553E+00
	IMODEII	1.18999170E+01	1.29181234E+01	1.29181234E+01	1.28233989E+01	2.70516757E-01
	QSMODE	1.29302712E+01	1.30074963E+01	1.29878365E+01	1.29700709E+01	3.77422203E-02
	DQSMODE	1.29302712E+01	1.30071808E+01	1.29302749E+01	1.29636266E+01	3.85095763E-02
M24	DE	5.67249516E+00	1.30578327E+01	7.63388048E+00	7.73326649E+00	1.97149160E+00
	FA	5.67442948E+00	1.13321479E+01	7.36444737E+00	7.38603485E+00	1.56783676E+00
	TLBO	5.67249517E+00	1.13161926E+01	6.47222657E+00	7.30457983E+00	1.66977805E+00
	SA	5.96452964E+00	1.22414909E+01	9.14064121E+00	8.61236049E+00	1.40163526E+00
	GA	6.15974593E+00	1.47654283E+02	8.46533413E+00	1.99595925E+01	3.69077893E+01
	CMAES	6.46387327E+00	1.89620211E+02	1.89620211E+02	1.19620084E+02	8.62210697E+01
	PSO	5.68460221E+00	1.59365069E+02	7.69194917E+01	5.63766359E+01	5.04651536E+01
	BAS	1.26721026E+01	2.20671823E+02	1.89048467E+01	3.72246009E+01	5.66562976E+01
	ABC	5.90317537E+00	9.12699521E+00	6.46892450E+00	6.65676188E+00	6.20699694E-01
	WOA	5.81366950E+00	1.19416548E+02	7.69047710E+01	5.35337942E+01	3.50990438E+01
	MFO	7.54815114E+00	1.96520523E+01	1.30544973E+01	1.32061565E+01	2.88685516E+00
	GWO	6.10411268E+00	1.34596811E+01	9.90792697E+00	1.01818857E+01	1.42276266E+00
	HHO	6.71857233E+00	1.01500882E+02	1.68799787E+01	3.73782376E+01	3.45983311E+01
	CSOA	5.68212331E+00	6.16616511E+00	5.73159676E+00	5.74711472E+00	9.23923483E-02
	CSO	7.57172335E+00	1.60567343E+01	1.19965133E+01	1.21089836E+01	2.29748397E+00
	IMODEII	5.67249516E+00	1.13161926E+01	5.67249516E+00	6.01650837E+00	1.18149070E+00
	QSMODE	5.67359179E+00	1.13889611E+01	6.12306022E+00	7.21531854E+00	1.80775365E+00
	DQSMODE	5.68372928E+00	9.18276108E+00	5.68422867E+00	6.44576266E+00	1.40056427E+00

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M25-M28).

M	Alg.	Best	Worst	Median	Mean	SD
M25	DE	8.06328429E+00	1.11940112E+01	1.11940112E+01	1.02487267E+01	1.27869366E+00
	FA	8.06702565E+00	1.12363360E+01	1.02672568E+01	9.84785080E+00	1.44624071E+00
	TLBO	8.06328429E+00	1.11940112E+01	8.06328429E+00	8.27709311E+00	6.68984243E-01
	SA	8.45101388E+00	1.21834404E+01	8.90095665E+00	9.83477239E+00	1.51595013E+00
	GA	8.28453994E+00	1.57498666E+02	1.17426296E+01	2.10884629E+01	3.64901413E+01
	CMAES	1.24721493E+01	4.47642620E+02	3.47277913E+01	1.47602025E+02	1.46287167E+02
	PSO	1.05614885E+01	2.08271540E+02	1.24609927E+02	1.06088257E+02	5.79717570E+01
	BAS	1.60992812E+01	3.64390271E+02	2.58439785E+01	7.26443602E+01	1.12561571E+02
	ABC	8.50563519E+00	1.21619346E+01	9.80686982E+00	9.86001418E+00	8.40900944E-01
	WOA	9.57481177E+00	1.23584579E+02	1.18229981E+01	2.24378474E+01	3.29241024E+01
	MFO	1.00250478E+01	1.76151662E+01	1.16979202E+01	1.23981200E+01	2.00898776E+00
	GWO	8.06589603E+00	9.87219804E+01	1.05512317E+01	1.28164682E+01	1.62817445E+01
	HHO	9.22374219E+00	1.89380983E+02	1.11925787E+01	2.55087248E+01	4.35884928E+01
	CSOA	8.58992736E+00	9.87688815E+01	1.14314709E+01	2.31033939E+01	3.02009811E+01
	CSO	8.42627989E+00	1.69507041E+01	1.23368515E+01	1.20595149E+01	2.76882423E+00
	IMODEII	7.41661237E+00	9.86278407E+01	8.06328429E+00	1.08449898E+01	1.65825026E+01
	QSMODE	7.44526301E+00	8.23579320E+00	8.23542647E+00	8.17073720E+00	1.49355721E-01
	DQSMODE	8.23292656E+00	8.23579339E+00	8.23579287E+00	8.23533853E+00	9.78986743E-04
M26	DE	1.24579722E+01	1.49778180E+01	1.40000000E+01	1.38790257E+01	5.11666761E-01
	FA	1.24587011E+01	1.49869602E+01	1.40010687E+01	1.39639572E+01	4.79076831E-01
	TLBO	1.24579722E+01	1.49778180E+01	1.24579722E+01	1.26846313E+01	6.44495390E-01
	SA	1.26650810E+01	1.60344871E+01	1.37103980E+01	1.38206077E+01	9.63984432E-01
	GA	1.26876006E+01	1.93160560E+02	1.46818424E+01	2.06197299E+01	3.26082507E+01
	CMAES	1.25790668E+01	3.30051676E+02	2.42220014E+01	8.56061662E+01	1.15618889E+02
	PSO	1.25100795E+01	4.45558132E+02	1.41844561E+01	5.28074194E+01	9.73888091E+01
	BAS	1.94433918E+01	5.08853191E+02	2.70781618E+01	9.19782215E+01	1.49665368E+02
	ABC	1.27351842E+01	1.40812752E+01	1.31290645E+01	1.32288214E+01	3.56400357E-01
	WOA	1.24587431E+01	1.85465748E+02	1.24877767E+01	1.86840146E+01	3.15362182E+01
	MFO	1.24579722E+01	2.30330255E+01	1.40000106E+01	1.56274337E+01	2.51265355E+00
	GWO	1.24645063E+01	1.53626791E+01	1.26504150E+01	1.31697514E+01	1.07393843E+00
	HHO	1.25419057E+01	1.96335697E+01	1.39689644E+01	1.44791142E+01	1.95833748E+00
	CSOA	1.24640315E+01	1.55893506E+01	1.25363104E+01	1.27577179E+01	6.23581971E-01
	CSO	1.28200892E+01	1.79942783E+01	1.51880207E+01	1.50576611E+01	1.62378133E+00
	IMODEII	1.24579722E+01	1.24579722E+01	1.24579722E+01	1.24579722E+01	7.70774849E-15
	QSMODE	1.24579722E+01	1.24579879E+01	1.24579722E+01	1.24579737E+01	4.73985663E-06
	DQSMODE	1.24579722E+01	1.24579722E+01	1.24579722E+01	1.24579722E+01	1.01536058E-08
M27	DE	1.47894623E+01	2.44668012E+01	1.79559875E+01	1.97609552E+01	3.40649150E+00
	FA	1.47901148E+01	1.70348309E+01	1.69349092E+01	1.65955815E+01	8.00693794E-01
	TLBO	1.62840930E+01	2.48220460E+01	1.89127997E+01	1.98080135E+01	2.64604430E+00
	SA	1.79043152E+01	1.87362448E+01	1.82328406E+01	1.82701261E+01	2.03375877E-01
	GA	1.49942769E+01	4.71622608E+01	2.05272185E+01	2.25354869E+01	7.03217585E+00
	CMAES	2.58838455E+01	7.46051507E+02	2.96076394E+02	3.03016649E+02	2.28524984E+02
	PSO	1.65265494E+01	8.33965411E+02	2.50874976E+02	2.77994891E+02	1.75278423E+02
	BAS	5.46101020E+01	1.80861413E+03	1.06322219E+03	1.00739651E+03	4.79370745E+02
	ABC	1.72421855E+01	2.18964099E+01	1.82157577E+01	1.85133805E+01	1.13381308E+00
	WOA	1.50480134E+01	5.28401613E+02	1.83511049E+01	6.08475674E+01	1.35683767E+02
	MFO	2.03640792E+01	5.70308512E+01	2.31703443E+01	2.50125300E+01	6.46347519E+00
	GWO	1.49098618E+01	1.84702519E+01	1.70396893E+01	1.67598375E+01	8.08562736E-01
	HHO	1.85086452E+01	3.68834651E+01	2.32573641E+01	2.45161153E+01	4.61551886E+00
	CSOA	1.45514799E+01	1.48696261E+02	1.74883730E+01	3.69097917E+01	4.48205209E+01
	CSO	1.82960573E+01	3.19834851E+01	2.17270603E+01	2.21359582E+01	3.24231603E+00
	IMODEII	1.47894623E+01	1.47894623E+01	1.47894623E+01	1.47894623E+01	1.63539307E-14
	QSMODE	1.48027540E+01	1.49525330E+01	1.49525116E+01	1.49471341E+01	2.72802334E-02
	DQSMODE	1.49502602E+01	1.49526870E+01	1.49525041E+01	1.49519313E+01	7.11531050E-04
M28	DE	9.80746950E+00	1.82303509E+01	1.07671320E+01	1.22399917E+01	2.69353179E+00
	FA	1.07738423E+01	1.48512146E+02	1.50211358E+01	1.93457500E+01	2.47672562E+01
	TLBO	9.82142185E+00	3.13184275E+02	1.07751945E+01	7.32482797E+01	1.04958051E+02
	SA	1.14273293E+01	2.38961923E+01	1.20712927E+01	1.54230932E+01	4.56770823E+00
	GA	1.10147047E+01	3.86959918E+02	1.96251448E+02	1.63194981E+02	1.36554084E+02
	CMAES	3.39248793E+01	1.44243138E+03	8.20499336E+02	7.82930720E+02	3.37626478E+02
	PSO	1.29766009E+02	9.13207958E+02	4.00335967E+02	4.02337918E+02	1.97847439E+02
	BAS	4.73370468E+02	1.88534616E+03	8.34023351E+02	9.32614726E+02	3.46669564E+02
	ABC	1.10897584E+01	1.69613755E+01	1.20797168E+01	1.26240117E+01	1.46024004E+00
	WOA	1.14903289E+01	2.84910261E+02	1.25964917E+02	1.09507600E+02	9.21182165E+01
	MFO	1.07820663E+01	4.24981300E+02	2.19715369E+01	7.25001318E+01	1.23203140E+02
	GWO	1.02700281E+01	4.03952149E+02	1.99370349E+01	1.01411195E+02	1.05322560E+02
	HHO	1.21352480E+01	4.78736168E+02	1.57175810E+02	1.60811601E+02	1.61158456E+02
	CSOA	9.93453825E+00	3.10334689E+02	7.16209632E+01	9.23198272E+01	8.99088158E+01
	CSO	1.17734379E+01	4.05312692E+02	1.79591103E+02	1.69765663E+02	1.50609299E+02
	IMODEII	9.80683571E+00	3.11172318E+02	1.24873940E+02	8.44455006E+01	8.30518625E+01
	QSMODE	1.08214580E+01	4.53091584E+01	1.80622341E+01	1.82772264E+01	5.56064657E+00
	DQSMODE	1.80611385E+01	1.81776085E+01	1.80620066E+01	1.80875837E+01	4.63814576E-02

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M29-M32).

M	Alg.	Best	Worst	Median	Mean	SD
M29	DE	1.02704832E+01	2.04810705E+01	1.02704832E+01	1.15775590E+01	2.68943478E+00
	FA	1.02768328E+01	1.82500403E+01	1.02808861E+01	1.11198018E+01	2.42208175E+00
	TLBO	1.02704832E+01	1.02403773E+02	1.09033700E+01	2.48895292E+01	3.22425057E+01
	SA	1.12229550E+01	1.09598606E+02	1.17940118E+01	1.66154330E+01	1.78767380E+01
	GA	1.08307778E+01	2.67766872E+02	1.31764023E+01	3.33903486E+01	5.37289291E+01
	CMAES	2.03750945E+01	3.57762442E+02	3.23899969E+02	2.67658020E+02	1.11951484E+02
	PSO	1.26299356E+01	7.03818867E+02	2.26892274E+02	2.62212382E+02	1.50246710E+02
	BAS	2.48427623E+01	1.64943935E+03	6.26091355E+02	6.49886855E+02	3.93941248E+02
	ABC	1.05817695E+01	1.14526731E+01	1.08860206E+01	1.09497046E+01	2.49856016E-01
	WOA	1.23226321E+01	1.66481230E+02	9.45332256E+01	7.75330185E+01	6.38457706E+01
	MFO	1.16795306E+01	1.92737067E+02	1.84709067E+01	4.22553189E+01	6.02045205E+01
	GWO	1.03215227E+01	1.00811759E+02	1.10889846E+01	3.38813392E+01	3.76012786E+01
	HHO	1.72811572E+01	1.67311051E+02	1.16880040E+02	1.17012661E+02	4.52378481E+01
	CSOA	1.03061922E+01	1.72128392E+02	9.62625927E+01	6.99940752E+01	5.67674006E+01
	CSO	1.18625757E+01	1.40305502E+02	1.63089221E+01	3.84688221E+01	4.25708592E+01
	IMODEII	1.02704832E+01	9.40218877E+01	9.40218877E+01	6.38081083E+01	4.04380932E+01
	QSMODE	1.04141772E+01	1.04781429E+01	1.04776684E+01	1.04747343E+01	1.18471950E-02
	DQSMODE	1.04526999E+01	1.04777036E+01	1.04776754E+01	1.04760079E+01	4.76321599E-03
M30	DE	7.63436682E+00	1.49079935E+02	1.80631743E+01	2.61592549E+01	3.49100486E+01
	FA	7.63783532E+00	1.54007801E+02	1.80847380E+01	5.88882235E+01	5.71077670E+01
	TLBO	7.63436682E+00	1.68261092E+02	1.80631743E+01	2.89305577E+01	4.02809347E+01
	SA	1.00202490E+01	2.64699939E+02	2.23337141E+01	4.96370660E+01	6.72574561E+01
	GA	9.11589088E+00	6.97303037E+02	2.04959269E+02	2.57353701E+02	2.20069243E+02
	CMAES	4.02405330E+01	7.76734377E+02	7.76734377E+02	6.68400901E+02	1.83020505E+02
	PSO	1.12705619E+01	9.08786518E+02	1.45077137E+02	2.29410252E+02	2.35663578E+02
	BAS	5.30705791E+02	3.31342672E+03	1.54047888E+03	1.69925891E+03	6.41116223E+02
	ABC	1.14404429E+01	2.82237078E+01	2.24832565E+01	2.23485007E+01	3.64014141E+00
	WOA	9.26337480E+00	3.32939750E+02	6.96962445E+01	9.78715493E+01	8.38434027E+01
	MFO	1.46047554E+01	5.86186889E+02	2.78459500E+02	2.16148080E+02	1.66869234E+02
	GWO	7.63812773E+00	4.02135066E+02	1.60181729E+02	1.54149096E+02	1.00120069E+02
	HHO	8.73103800E+00	3.30048041E+02	7.55822602E+01	7.62669706E+01	6.87324943E+01
	CSOA	7.65959039E+00	3.21064540E+02	6.71132900E+01	7.65344192E+01	6.89455683E+01
	CSO	1.19510508E+01	3.24069190E+02	2.23740520E+02	1.95180712E+02	8.08642715E+01
	IMODEII	7.63436682E+00	6.43714385E+01	6.43714385E+01	4.83931978E+01	2.49750306E+01
	QSMODE	1.79393015E+01	4.68600326E+01	1.83525742E+01	2.49725271E+01	1.12198743E+01
	DQSMODE	1.79282761E+01	4.46769800E+01	1.82141567E+01	2.16344608E+01	8.88064726E+00
M31	DE	1.98216585E+01	2.48060333E+01	2.00809140E+01	2.06338306E+01	1.53620680E+00
	FA	1.98235530E+01	2.41711476E+01	2.00829063E+01	2.03791036E+01	1.08327016E+00
	TLBO	1.98216585E+01	2.12494375E+01	2.00809140E+01	2.01687334E+01	2.89312082E-01
	SA	2.03135584E+01	2.55593255E+01	2.05187861E+01	2.10067426E+01	1.10409554E+00
	GA	1.99136584E+01	3.11584018E+02	2.09224964E+01	3.18812420E+01	5.31787406E+01
	CMAES	2.72823626E+01	7.14369722E+02	4.11791446E+02	3.12308652E+02	2.22424197E+02
	PSO	2.09238059E+01	5.81754564E+02	2.89739414E+02	3.42863045E+02	1.57594080E+02
	BAS	3.64657620E+01	1.98006829E+03	6.53983456E+02	8.23403110E+02	4.57448758E+02
	ABC	1.99939413E+01	2.15489264E+01	2.03529858E+01	2.05118683E+01	4.70724249E-01
	WOA	2.04472081E+01	2.77780539E+02	2.09637684E+01	8.79776568E+01	1.12836427E+02
	MFO	2.10238475E+01	4.04085865E+02	3.00968096E+01	5.44197784E+01	9.51703249E+01
	GWO	1.98285648E+01	2.32377102E+01	2.02425792E+01	2.03423176E+01	6.23410871E-01
	HHO	2.05674687E+01	2.83687989E+02	2.21018934E+01	6.52821630E+01	9.66648444E+01
	CSOA	1.98403333E+01	2.13557907E+01	1.98694405E+01	1.99933127E+01	3.55858247E-01
	CSO	2.02443621E+01	3.60456934E+01	2.12751490E+01	2.23282762E+01	3.05384307E+00
	IMODEII	2.00809140E+01	2.00809140E+01	2.00809140E+01	2.00809140E+01	3.95833421E-15
	QSMODE	2.00809294E+01	2.00865107E+01	2.00812250E+01	2.00815650E+01	1.05489046E-03
	DQSMODE	2.00809222E+01	2.00823622E+01	2.00810168E+01	2.00811778E+01	3.25394027E-04
M32	DE	1.43743827E+01	2.41275138E+01	1.59266899E+01	1.70934979E+01	2.82510789E+00
	FA	1.43750762E+01	1.85778550E+01	1.78966143E+01	1.67155610E+01	1.87308142E+00
	TLBO	1.43743843E+01	1.69896604E+02	1.84675326E+01	2.67936185E+01	3.57856694E+01
	SA	1.55828328E+01	3.58791983E+01	2.00557161E+01	1.96343479E+01	3.69308496E+00
	GA	1.37732054E+01	1.73178872E+02	1.83943055E+01	2.86351409E+01	3.62910477E+01
	CMAES	2.47906219E+01	4.87479023E+02	2.56857145E+02	2.56657347E+02	1.63315668E+02
	PSO	1.69885946E+01	6.57499152E+02	1.89750636E+02	2.46098579E+02	1.33247572E+02
	BAS	3.81849946E+02	2.58784564E+03	1.58284419E+03	1.54925126E+03	6.02053108E+02
	ABC	1.44070089E+01	1.88117687E+01	1.44901914E+01	1.50624744E+01	1.21683380E+00
	WOA	1.74290691E+01	2.24469410E+01	2.10994276E+01	2.08988643E+01	7.77272915E-01
	MFO	1.91959957E+01	3.82020154E+02	2.52198663E+01	6.99048267E+01	1.09537650E+02
	GWO	1.43857795E+01	1.79747163E+02	1.83606278E+01	3.35189496E+01	4.86784723E+01
	HHO	1.64529218E+01	2.27669284E+02	2.34974508E+01	3.90723163E+01	4.99822432E+01
	CSOA	1.43977180E+01	1.78983973E+01	1.46373353E+01	1.50348680E+01	9.05567124E-01
	CSO	1.82944891E+01	3.32530861E+02	2.32675002E+01	7.17339941E+01	8.69377371E+01
	IMODEII	1.34455789E+01	1.91903942E+02	1.71509914E+01	5.30027480E+01	6.69846684E+01
	QSMODE	1.56285606E+01	1.89026464E+01	1.62548436E+01	1.69764785E+01	1.14375959E+00
	DQSMODE	1.62454325E+01	1.85180406E+01	1.62507684E+01	1.64776134E+01	6.91296062E-01

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (33-M36).

M	Alg.	Best	Worst	Median	Mean	SD
M33	DE	1.45678165E+01	3.23398170E+01	2.02032282E+01	2.08992849E+01	5.46845285E+00
	FA	1.45691208E+01	3.03288846E+01	1.60311237E+01	1.86368291E+01	4.69072333E+00
	TLBO	1.65276740E+01	1.71684035E+01	1.67429510E+01	1.67581355E+01	1.48877388E-01
	SA	1.82614318E+01	4.72552852E+01	2.55784544E+01	2.72717336E+01	8.66910628E+00
	GA	1.47887067E+01	2.35280573E+02	2.77202964E+01	4.71124002E+01	5.75018154E+01
	CMAES	7.40512376E+01	1.19202741E+03	6.78813099E+02	5.73401297E+02	2.77234288E+02
	PSO	2.58778713E+02	2.02325578E+03	9.64264474E+02	1.03660226E+03	5.03397103E+02
	BAS	2.47725929E+03	8.75042265E+03	5.02610498E+03	5.11987817E+03	1.49879302E+03
	ABC	1.46316581E+01	3.25317869E+01	1.59139862E+01	1.99882520E+01	6.70933179E+00
	WOA	1.47831164E+01	2.80031387E+01	1.65841177E+01	1.72124656E+01	2.43096006E+00
	MFO	2.46622440E+01	3.42244504E+02	4.00799128E+01	7.64041379E+01	8.99161836E+01
	GWO	1.54876203E+01	1.59305846E+02	1.69588027E+01	2.29016439E+01	2.62144116E+01
	HHO	1.84189906E+01	5.89740362E+01	2.55369027E+01	2.69485125E+01	7.94922875E+00
	CSOA	1.53163387E+01	1.96196115E+01	1.60308521E+01	1.66508979E+01	1.22192525E+00
	CSO	2.15510441E+01	4.11391912E+02	4.10923424E+01	9.06735869E+01	1.04943629E+02
	IMODEII	1.57012618E+01	2.09208275E+02	1.57012618E+01	2.57255441E+01	3.97930559E+01
	QSMODE	1.57098280E+01	1.57828673E+01	1.57342637E+01	1.57355618E+01	1.76837001E-02
	DQSMODE	1.57084888E+01	1.58116784E+01	1.57263998E+01	1.57292979E+01	1.72616565E-02
M34	DE	1.73490969E+01	3.49960739E+01	2.43652899E+01	2.55459909E+01	4.96559736E+00
	FA	1.67556204E+01	2.61559066E+01	2.43671434E+01	2.26198433E+01	3.42064363E+00
	TLBO	1.84168843E+01	4.08974469E+01	2.01135135E+01	2.09670213E+01	3.93369952E+00
	SA	1.98868557E+01	4.44781047E+01	2.73289332E+01	2.62372175E+01	4.79576017E+00
	GA	1.77564984E+01	7.51160306E+01	2.56543073E+01	2.88903931E+01	1.16289280E+01
	CMAES	4.75519887E+01	8.20045419E+02	5.51486777E+02	4.99523296E+02	2.24733218E+02
	PSO	4.07367773E+02	2.12221035E+03	9.60605466E+02	1.04311163E+03	4.90165003E+02
	BAS	2.05319669E+03	7.90434050E+03	5.70454090E+03	5.19376850E+03	1.60890714E+03
	ABC	1.73754157E+01	2.76915218E+01	2.19033306E+01	2.11666865E+01	3.58265069E+00
	WOA	2.02728742E+01	3.02847277E+01	2.26082632E+01	2.29635426E+01	2.21810470E+00
	MFO	3.03475124E+01	5.03673359E+01	3.42448602E+01	3.74616165E+01	6.39673438E+00
	GWO	1.69899420E+01	5.64437868E+01	2.09256781E+01	2.36527023E+01	7.95551649E+00
	HHO	2.02291737E+01	2.06563993E+02	3.09526743E+01	3.69504803E+01	3.27643937E+01
	CSOA	1.75010826E+01	2.23827519E+01	1.88385275E+01	1.90665341E+01	1.14939200E+00
	CSO	2.02499100E+01	5.87228515E+01	2.43436866E+01	2.70015985E+01	8.38444104E+00
	IMODEII	1.69135789E+01	1.91806753E+01	1.70211418E+01	1.79930698E+01	1.13055626E+00
	QSMODE	1.69591492E+01	1.93672609E+01	1.69691246E+01	1.77545789E+01	1.11911070E+00
	DQSMODE	1.69578377E+01	1.93671355E+01	1.70355100E+01	1.78399170E+01	1.12792335E+00
M35	DE	1.92875562E+01	5.11929445E+01	2.63014060E+01	2.68684904E+01	8.21561936E+00
	FA	1.76242731E+01	1.83617032E+02	2.09671192E+01	3.01573399E+01	2.99843681E+01
	TLBO	1.92110853E+01	2.03810289E+02	3.20618505E+01	4.56955133E+01	3.87004403E+01
	SA	2.21695466E+01	3.27447083E+01	2.40303360E+01	2.40618524E+01	1.81182258E+00
	GA	1.94146385E+01	2.12460081E+02	3.08800381E+01	4.31656851E+01	3.74289121E+01
	CMAES	3.29564360E+01	5.69154780E+02	1.16593334E+02	2.12846226E+02	2.09702517E+02
	PSO	3.43409736E+01	3.66516113E+03	6.78294440E+02	9.11529204E+02	7.18776734E+02
	BAS	1.64564306E+03	8.15880185E+03	4.80809423E+03	5.07859309E+03	1.65243403E+03
	ABC	2.00988164E+01	5.33006921E+01	2.45178537E+01	2.86754866E+01	8.76071864E+00
	WOA	1.42598942E+01	1.91499590E+02	1.89785764E+02	1.20438687E+02	8.39238646E+01
	MFO	2.59678218E+01	7.32027416E+01	3.46325540E+01	3.53130221E+01	8.26808122E+00
	GWO	1.56988102E+01	3.66102052E+02	3.52543122E+01	6.92032042E+01	8.16777651E+01
	HHO	1.97751537E+01	1.93989858E+02	1.48944993E+02	1.14340661E+02	7.71286491E+01
	CSOA	1.87707242E+01	4.49734191E+02	5.44114525E+01	1.29747391E+02	1.26101981E+02
	CSO	2.10105713E+01	1.45484331E+03	3.30356889E+02	3.95196402E+02	3.15308528E+02
	IMODEII	1.40889089E+01	1.89750456E+02	1.01390818E+02	7.58960741E+01	5.67770721E+01
	QSMODE	1.40919925E+01	3.13364364E+01	2.86633786E+01	2.39300440E+01	6.96062817E+00
	DQSMODE	1.40933250E+01	2.94585384E+01	2.88760741E+01	2.57666449E+01	6.05255269E+00
M36	DE	9.71863706E+00	3.10998838E+01	1.92381161E+01	1.90936168E+01	4.11433774E+00
	FA	6.69321226E+00	1.61419668E+02	1.51254181E+01	2.92416440E+01	4.06389435E+01
	TLBO	1.49226513E+01	2.53755203E+02	2.04235496E+01	3.66770329E+01	5.72212594E+01
	SA	1.24919492E+01	4.66514092E+01	1.77027067E+01	1.82597016E+01	6.97794145E+00
	GA	1.39317284E+01	4.07835180E+02	2.45168880E+01	8.77164157E+01	1.08266821E+02
	CMAES	5.23354494E+01	1.42914640E+03	5.71504112E+02	5.30542070E+02	2.11687352E+02
	PSO	9.24309764E+00	1.13296112E+03	2.33613200E+02	3.34117355E+02	2.74828256E+02
	BAS	6.71856716E+02	3.64202853E+03	2.33980396E+03	2.09884307E+03	6.98224784E+02
	ABC	1.18466445E+01	3.23380276E+01	1.74463216E+01	1.88971764E+01	4.28502765E+00
	WOA	6.71477816E+00	1.99192571E+02	6.99670722E+00	3.13775790E+01	4.34184836E+01
	MFO	1.72211037E+01	5.71227294E+02	4.38319808E+01	1.41543404E+02	1.49798069E+02
	GWO	1.37530757E+01	2.70285898E+02	2.24401962E+01	5.57050595E+01	6.77888357E+01
	HHO	8.30359426E+00	1.98489504E+02	1.27721399E+01	3.87778754E+01	5.67143520E+01
	CSOA	6.72101306E+00	1.08411731E+02	1.01731739E+01	2.67777993E+01	3.05213358E+01
	CSO	2.06726429E+01	8.25447296E+02	1.48687754E+02	1.86327255E+02	1.93627819E+02
	IMODEII	6.69275558E+00	1.61801567E+02	4.06755123E+01	4.89696693E+01	4.80492475E+01
	QSMODE	1.49062336E+01	2.08628691E+01	2.08200454E+01	1.96518775E+01	2.39454318E+00
	DQSMODE	1.49058779E+01	2.08723954E+01	2.08086549E+01	1.84887274E+01	2.92513745E+00

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M37-M40).

M	Alg.	Best	Worst	Median	Mean	SD
M37	DE	1.85115613E+01	1.73501633E+02	2.72141137E+01	5.10517268E+01	5.30555101E+01
	FA	1.39679975E+01	4.28108563E+02	1.89001789E+01	6.76694742E+01	1.02209537E+02
	TLBO	2.29340881E+01	4.82339560E+02	1.57946846E+02	1.51522686E+02	1.26034450E+02
	SA	1.96108388E+01	6.33671995E+01	2.73418702E+01	3.07793372E+01	1.38120236E+01
	GA	1.90078648E+01	5.51955138E+02	4.16149766E+01	1.31265142E+02	1.49875756E+02
	CMAES	2.33761358E+02	1.78019796E+03	4.73007195E+02	5.90361900E+02	3.60446009E+02
	PSO	2.54287505E+02	2.08770613E+03	1.09126771E+03	1.05260445E+03	3.94031135E+02
	BAS	3.81330044E+03	1.02307849E+04	7.31541356E+03	7.08505310E+03	1.62634082E+03
	ABC	1.49578565E+01	4.11296835E+01	2.48352049E+01	2.74387437E+01	7.31709330E+00
	WOA	1.40575236E+01	2.26900838E+02	9.41486800E+01	9.97303609E+01	5.47737597E+01
	MFO	2.27640224E+01	7.74573902E+02	2.25128692E+02	2.36289833E+02	2.00781142E+02
	GWO	1.69606145E+01	6.85306164E+02	1.45258217E+02	1.59610558E+02	1.55263695E+02
	HHO	5.19719868E+01	4.00471211E+02	2.13725104E+02	2.03609359E+02	7.42897312E+01
	CSOA	1.43487997E+01	2.51816898E+02	1.26683724E+02	1.31858944E+02	5.73684027E+01
	CSO	4.22082483E+01	2.38182416E+03	1.01921716E+03	1.04712082E+03	6.11773567E+02
	IMODEII	2.27267859E+01	2.95438008E+02	2.11579397E+02	1.95156860E+02	5.40253666E+01
	QSMODE	2.29945197E+01	6.16323929E+01	4.51693358E+01	4.43230655E+01	1.47924942E+01
	DQSMODE	2.30652062E+01	5.97867614E+01	4.49097985E+01	4.54286572E+01	1.41486989E+01
M38	DE	1.33373373E+01	1.33373392E+01	1.33373373E+01	1.33373373E+01	3.53232648E-07
	FA	1.33412336E+01	1.33513011E+01	1.33463583E+01	1.33460044E+01	2.48129971E-03
	TLBO	1.33373373E+01	1.33380766E+01	1.33373374E+01	1.33373924E+01	1.76890653E-04
	SA	1.33893445E+01	1.35282955E+01	1.34575848E+01	1.34614553E+01	3.67925481E-02
	GA	1.34319145E+01	1.54859670E+01	1.39583098E+01	1.40522258E+01	4.88492674E-01
	CMAES	1.43409814E+01	6.32289611E+02	1.63444444E+01	1.06045357E+02	2.07832828E+02
	PSO	1.33473412E+01	3.15114095E+02	1.42457159E+01	6.44310085E+01	1.14029051E+02
	BAS	1.42702983E+01	1.83804303E+01	1.52390922E+01	1.53730945E+01	8.95619112E-01
	ABC	1.34248503E+01	1.37739723E+01	1.35951093E+01	1.35871226E+01	8.73351485E-02
	WOA	1.33498494E+01	1.64943746E+01	1.35720158E+01	1.40092345E+01	8.34383983E-01
	MFO	1.33373373E+01	1.34070458E+01	1.33374913E+01	1.33478283E+01	1.94858537E-02
	GWO	1.33386893E+01	1.38573827E+01	1.33408664E+01	1.33913877E+01	1.21284981E-01
	HHO	1.34042467E+01	1.58568911E+01	1.41880418E+01	1.42817081E+01	6.35823493E-01
	CSOA	1.33461983E+01	2.05337073E+01	1.33903910E+01	1.37023230E+01	1.35168047E+00
	CSO	1.34611952E+01	1.42523269E+01	1.37008524E+01	1.37521761E+01	2.42975769E-01
	IMODEII	1.33373373E+01	1.33373373E+01	1.33373373E+01	1.33373373E+01	3.56799424E-15
	QSMODE	1.36042924E+01	1.36080171E+01	1.36044106E+01	1.36047712E+01	7.87694818E-04
	DQSMODE	1.36042924E+01	1.36061534E+01	1.36049250E+01	1.36047196E+01	4.94173856E-04
M39	DE	1.52100612E+01	1.98062066E+01	1.52100612E+01	1.53632661E+01	8.39137501E-01
	FA	1.52105783E+01	1.69388906E+01	1.52114667E+01	1.52690529E+01	3.15382176E-01
	TLBO	1.52100612E+01	1.69580411E+01	1.52111048E+01	1.56403960E+01	7.16294123E-01
	SA	1.54352082E+01	1.79458053E+01	1.56329082E+01	1.59203650E+01	7.74711803E-01
	GA	1.53324585E+01	2.30539815E+01	1.59811787E+01	1.67873421E+01	2.06930764E+00
	CMAES	2.33840135E+01	5.28423366E+02	3.55589396E+01	1.46587700E+02	1.66659750E+02
	PSO	1.53142376E+01	2.75267978E+02	2.18068290E+01	9.15690935E+01	9.87140815E+01
	BAS	2.49500994E+01	6.79135817E+02	4.35558859E+01	1.27130354E+02	1.98583731E+02
	ABC	1.52552522E+01	1.53736862E+01	1.53179405E+01	1.53199221E+01	3.02477804E-02
	WOA	1.52815850E+01	1.93661215E+02	1.61422388E+01	4.58524848E+01	6.64735860E+01
	MFO	1.52100612E+01	2.74764850E+01	2.23772021E+01	2.07136136E+01	4.03320921E+00
	GWO	1.52155082E+01	1.72015625E+01	1.52726604E+01	1.55699300E+01	6.75835294E-01
	HHO	1.58987831E+01	2.75151218E+01	1.84233745E+01	1.92744705E+01	3.02130868E+00
	CSOA	1.52210859E+01	2.17260570E+01	1.52522709E+01	1.56513445E+01	1.28363542E+00
	CSO	1.58628607E+01	2.28272199E+01	1.88523500E+01	1.88882659E+01	2.06324593E+00
	IMODEII	1.52100612E+01	1.52100612E+01	1.52100612E+01	1.52100612E+01	8.04617912E-15
	QSMODE	1.52114815E+01	1.52644174E+01	1.52629829E+01	1.52599239E+01	1.25109832E-02
	DQSMODE	1.52104946E+01	1.52635342E+01	1.52385846E+01	1.52379625E+01	2.58016790E-02
M40	DE	1.17005221E+01	1.26809314E+01	1.26809314E+01	1.26482510E+01	1.78997427E-01
	FA	1.17009022E+01	1.55038723E+01	1.26815768E+01	1.25796357E+01	6.80315966E-01
	TLBO	1.17005321E+01	1.33120691E+01	1.26809314E+01	1.22731052E+01	5.35160407E-01
	SA	1.19856158E+01	1.59538626E+01	1.24066992E+01	1.26197095E+01	8.40943034E-01
	GA	1.17417988E+01	1.80647500E+01	1.28575246E+01	1.30299470E+01	1.42897421E+00
	CMAES	1.68772271E+01	4.80277369E+02	2.39670231E+01	9.57471170E+01	1.54924729E+02
	PSO	1.16513766E+01	1.84626693E+01	1.27184234E+01	1.32117664E+01	1.63815645E+00
	BAS	1.98325566E+01	3.45541017E+01	2.87545197E+01	2.79164832E+01	4.51425861E+00
	ABC	1.17426448E+01	1.23908348E+01	1.18645695E+01	1.18950455E+01	1.46465378E-01
	WOA	1.15361786E+01	1.68597773E+01	1.17305420E+01	1.20680679E+01	1.14564936E+00
	MFO	1.26809314E+01	2.14158658E+01	1.72742399E+01	1.70741254E+01	2.07907656E+00
	GWO	1.16876720E+01	1.42042540E+01	1.17548680E+01	1.20239825E+01	7.46116936E-01
	HHO	1.18094735E+01	1.97001147E+01	1.45709778E+01	1.47088030E+01	1.77517178E+00
	CSOA	1.15345026E+01	1.17447432E+01	1.17142539E+01	1.16531950E+01	8.47147523E-02
	CSO	1.19773947E+01	2.07112459E+01	1.45016091E+01	1.46992090E+01	1.88984562E+00
	IMODEII	1.15266223E+01	1.17005221E+01	1.17005221E+01	1.16947254E+01	3.17496006E-02
	QSMODE	1.17005234E+01	1.17007733E+01	1.17005563E+01	1.17005754E+01	6.30789887E-05
	DQSMODE	1.17005233E+01	1.17006200E+01	1.17005626E+01	1.17005619E+01	3.88310837E-05

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M41-M44).

M	Alg.	Best	Worst	Median	Mean	SD
M41	DE	1.40612974E+01	2.31641221E+01	1.52864240E+01	1.59603582E+01	2.35370849E+00
	FA	1.34529867E+01	1.71701482E+01	1.40637696E+01	1.44951877E+01	9.30432174E-01
	TLBO	1.40612993E+01	2.38995263E+01	2.03697929E+01	1.94625007E+01	2.65137644E+00
	SA	1.55222902E+01	1.88284419E+01	1.67321541E+01	1.69920797E+01	1.01348497E+00
	GA	1.42998409E+01	2.71077974E+01	1.66748456E+01	1.79788436E+01	3.70036120E+00
	CMAES	2.25219923E+01	4.92004410E+02	3.94042317E+01	1.46916474E+02	1.72893832E+02
	PSO	1.66572441E+01	4.18496263E+02	2.78932306E+01	1.05738127E+02	1.13147022E+02
	BAS	4.63446722E+01	2.20624608E+03	7.42837868E+02	7.89338625E+02	5.08432720E+02
	ABC	1.41471711E+01	1.47130998E+01	1.43213498E+01	1.43435006E+01	1.32197816E-01
	WOA	1.32266996E+01	3.26287052E+02	1.52926218E+01	4.61850922E+01	9.49664586E+01
	MFO	1.71731858E+01	2.84830911E+01	2.34472511E+01	2.39181842E+01	2.87533793E+00
	GWO	1.32142710E+01	2.18932225E+01	1.38195728E+01	1.46651623E+01	2.37349570E+00
	HHO	1.57477159E+01	3.66984408E+01	2.00869980E+01	2.18490089E+01	4.83770215E+00
	CSOA	1.35947100E+01	1.22384896E+02	1.49045284E+01	2.59091095E+01	3.27231847E+01
	CSO	1.51450243E+01	5.20810549E+01	2.43630327E+01	2.63340714E+01	7.89639726E+00
	IMODEII	1.31386169E+01	1.36419932E+01	1.31386169E+01	1.32037636E+01	1.68350492E-01
	QSMODE	1.35842744E+01	1.42037724E+01	1.41927182E+01	1.40052774E+01	2.76675202E-01
	DQSMODE	1.35843422E+01	1.42038015E+01	1.35961316E+01	1.37735714E+01	2.83098473E-01
M42	DE	1.37892102E+01	1.80640788E+01	1.58289157E+01	1.58808365E+01	8.96263147E-01
	FA	1.37916558E+01	1.62881552E+01	1.58152126E+01	1.52332220E+01	8.52565665E-01
	TLBO	1.30395275E+01	1.88022447E+01	1.31451984E+01	1.44482890E+01	1.98726165E+00
	SA	1.49660659E+01	1.67442180E+01	1.62405447E+01	1.60619792E+01	5.42244765E-01
	GA	1.30865257E+01	3.07777841E+01	1.57286726E+01	1.65969134E+01	3.40687634E+00
	CMAES	1.85389230E+01	2.75253009E+02	2.52616241E+01	6.67108672E+01	8.09079099E+01
	PSO	1.44026634E+01	6.18535596E+02	8.68236536E+01	1.14294654E+02	1.25614364E+02
	BAS	2.95020945E+01	6.44618444E+02	7.18046025E+01	2.55503399E+02	2.31508901E+02
	ABC	1.47337715E+01	1.87666929E+01	1.65235339E+01	1.65045412E+01	7.94158421E-01
	WOA	1.30406085E+01	1.46153607E+01	1.34129320E+01	1.36948095E+01	6.30139637E-01
	MFO	1.47944887E+01	2.61347700E+01	1.93980696E+01	2.00107490E+01	2.18569839E+00
	GWO	1.30422751E+01	1.49526653E+01	1.39356709E+01	1.39428918E+01	6.50649286E-01
	HHO	1.38931320E+01	1.88319147E+01	1.54231600E+01	1.55633771E+01	1.21930468E+00
	CSOA	1.30471991E+01	1.42535776E+01	1.38814528E+01	1.37961483E+01	2.86315501E-01
	CSO	1.30658621E+01	2.98742071E+01	1.78865323E+01	1.85200599E+01	3.45446922E+00
	IMODEII	1.30395275E+01	1.30395275E+01	1.30395275E+01	1.30395275E+01	1.00763279E-13
	QSMODE	1.30395275E+01	1.30409282E+01	1.30395718E+01	1.30396130E+01	2.62770283E-04
	DQSMODE	1.30395275E+01	1.30400101E+01	1.30395275E+01	1.30395768E+01	1.19885314E-04
M43	DE	1.47222183E+01	2.12194267E+01	1.47222183E+01	1.55810744E+01	1.64201886E+00
	FA	1.47225303E+01	1.69101392E+01	1.47228004E+01	1.48958783E+01	5.56917061E-01
	TLBO	1.47222183E+01	2.32452799E+01	1.53540240E+01	1.65551602E+01	2.63949996E+00
	SA	1.51694782E+01	1.98402813E+01	1.55173739E+01	1.56386055E+01	8.10600842E-01
	GA	1.47757919E+01	2.97144925E+01	1.63780354E+01	1.74455475E+01	3.15587380E+00
	CMAES	2.18170503E+01	4.78614211E+02	2.90976963E+01	1.05328040E+02	1.49347248E+02
	PSO	1.64872464E+01	3.29798101E+02	2.41618801E+01	9.28672952E+01	1.00282664E+02
	BAS	3.47532771E+01	8.20245310E+02	6.76742445E+01	2.86112749E+02	3.02845272E+02
	ABC	1.47514725E+01	1.48682313E+01	1.47843751E+01	1.47897980E+01	2.45435317E-02
	WOA	1.49063325E+01	1.82215136E+01	1.52001455E+01	1.54837511E+01	8.07661211E-01
	MFO	1.48121651E+01	2.57757126E+01	2.12194305E+01	2.14095261E+01	1.96073470E+00
	GWO	1.47238247E+01	2.92103386E+01	1.48266284E+01	1.61917537E+01	3.71317813E+00
	HHO	1.60487531E+01	2.59116842E+01	1.70881544E+01	1.81814848E+01	2.43354485E+00
	CSOA	1.47348538E+01	1.53569982E+01	1.48289166E+01	1.48573700E+01	1.39368989E-01
	CSO	1.58973543E+01	3.26711584E+01	2.09969008E+01	2.15463420E+01	4.20571733E+00
	IMODEII	1.47222183E+01	1.47222183E+01	1.47222183E+01	1.47222183E+01	8.63959275E-15
	QSMODE	1.47225974E+01	1.47500272E+01	1.47499969E+01	1.47472308E+01	7.98833010E-03
	DQSMODE	1.47229827E+01	1.47500013E+01	1.47494655E+01	1.47469617E+01	8.12958634E-03
M44	DE	1.49429928E+01	6.21775749E+01	2.52983135E+01	2.73350372E+01	9.28013685E+00
	FA	1.29372862E+01	2.12208833E+02	2.27192464E+01	3.02166633E+01	3.54835784E+01
	TLBO	1.28588089E+01	9.60688929E+01	2.96934570E+01	4.13697439E+01	3.21430168E+01
	SA	2.10278787E+01	3.01700691E+01	2.62770682E+01	2.56249018E+01	2.77310328E+00
	GA	1.59596657E+01	4.63421357E+01	2.84787678E+01	2.86136867E+01	7.26221289E+00
	CMAES	3.22247353E+01	6.66997649E+02	4.50772812E+02	3.68547697E+02	2.00774631E+02
	PSO	2.92360928E+01	8.68512665E+02	2.49747563E+02	2.83798951E+02	1.85707901E+02
	BAS	1.38372375E+03	6.57901994E+03	4.19662527E+03	4.21847652E+03	1.16756140E+03
	ABC	2.04143875E+01	5.27139885E+01	3.29910912E+01	3.43057468E+01	8.78271386E+00
	WOA	1.37207565E+01	1.76446115E+02	9.45588230E+01	7.90263866E+01	5.94156327E+01
	MFO	2.64364234E+01	5.54177806E+01	3.75715029E+01	3.87599535E+01	7.84738450E+00
	GWO	1.28792039E+01	1.55989933E+02	1.63336619E+01	2.30904919E+01	2.58678230E+01
	HHO	1.89629435E+01	1.76617754E+02	1.26642531E+02	9.53359027E+01	6.00895772E+01
	CSOA	1.49706738E+01	1.85625402E+02	2.99111023E+01	7.01901359E+01	6.20976700E+01
	CSO	1.64105308E+01	4.31385192E+02	3.41635259E+01	8.49182507E+01	8.77274466E+01
	IMODEII	1.28531674E+01	9.34462440E+01	9.34462440E+01	5.67099963E+01	4.02185926E+01
	QSMODE	1.28724642E+01	2.29529871E+01	1.28736125E+01	1.46980789E+01	3.79387140E+00
	DQSMODE	1.28723224E+01	2.29524317E+01	1.28732359E+01	1.33683574E+01	2.00248713E+00

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M45-M48).

M	Alg.	Best	Worst	Median	Mean	SD
M45	DE	2.16327969E+01	3.58279027E+01	2.94275587E+01	2.85049412E+01	4.77161806E+00
	FA	1.95632189E+01	4.86027113E+01	2.28502250E+01	2.52759284E+01	7.28678354E+00
	TLBO	1.97775877E+01	5.95570561E+01	2.41798993E+01	2.75624774E+01	8.04203018E+00
	SA	2.43335361E+01	6.50817974E+01	2.57947743E+01	3.04662853E+01	1.28647824E+01
	GA	1.96106109E+01	5.35400333E+01	3.04857849E+01	3.15171805E+01	8.76500295E+00
	CMAES	3.35106863E+01	4.90698520E+02	4.13271060E+02	3.30545118E+02	1.78413139E+02
	PSO	3.02597184E+01	1.95175552E+03	3.33560889E+02	4.41179558E+02	3.99251029E+02
	BAS	6.81957827E+02	5.18341543E+03	3.49623123E+03	3.41182738E+03	1.14351115E+03
	ABC	3.45118289E+01	6.02412582E+01	4.68200198E+01	4.68632901E+01	7.80228038E+00
	WOA	1.90354467E+01	1.40432521E+02	1.96789579E+01	2.46072379E+01	2.19846661E+01
	MFO	2.54106317E+01	4.11737820E+02	3.30056578E+01	5.08026770E+01	7.02279751E+01
	GWO	1.98817959E+01	4.21715182E+01	2.37684768E+01	2.47264101E+01	4.21835756E+00
	HHO	1.96182573E+01	3.47787172E+01	2.62717807E+01	2.63542769E+01	3.73365956E+00
	CSOA	2.07301341E+01	3.51750467E+02	2.54834816E+01	5.07146349E+01	7.33139391E+01
	CSO	3.07950537E+01	5.05451928E+02	4.60759629E+01	8.93312527E+01	1.20837300E+02
	IMODEII	1.88917157E+01	1.97771140E+01	1.88917157E+01	1.89237438E+01	1.61338315E-01
	QSMODE	1.88919802E+01	1.93056594E+01	1.89024498E+01	1.90236455E+01	1.51593611E-01
	DQSMODE	1.88924308E+01	1.93302321E+01	1.88941690E+01	1.89924398E+01	1.43910999E-01
M46	DE	1.46545607E+01	2.54483265E+02	2.37509060E+01	3.20899895E+01	4.28060571E+01
	FA	9.55607121E+00	2.29159269E+02	1.89016018E+01	2.95418674E+01	4.11490248E+01
	TLBO	1.00095848E+01	7.28565530E+01	3.71328738E+01	4.21483140E+01	2.53994980E+01
	SA	1.99964590E+01	3.50718138E+01	2.25704058E+01	2.42141161E+01	4.11639863E+00
	GA	1.50260567E+01	3.00887457E+02	3.05490373E+01	8.47841683E+01	8.95843984E+01
	CMAES	1.72696776E+02	1.47258519E+03	4.53360135E+02	4.75138224E+02	2.73843156E+02
	PSO	1.26127503E+02	1.53724323E+03	2.87146535E+02	3.52813874E+02	2.86058830E+02
	BAS	2.50509980E+03	7.70865612E+03	5.71723693E+03	5.47111399E+03	1.18957118E+03
	ABC	9.62311524E+00	4.79252125E+01	1.64724890E+01	2.00949252E+01	1.04590301E+01
	WOA	1.23404738E+01	7.25000000E+01	1.35856296E+01	2.96870394E+01	2.58607173E+01
	MFO	2.47333475E+01	9.57405393E+02	4.15057361E+01	1.03525163E+02	1.83124134E+02
	GWO	1.01593165E+01	1.48088254E+02	1.57884676E+01	4.00182439E+01	3.86332980E+01
	HHO	2.90201911E+01	7.26970801E+01	7.25555088E+01	6.96888331E+01	1.09803527E+01
	CSOA	1.32217582E+01	2.43202502E+02	9.49475047E+01	8.64353726E+01	6.42803298E+01
	CSO	1.31768303E+01	6.66803387E+02	1.13107260E+02	1.59053116E+02	1.56789966E+02
	IMODEII	9.55581760E+00	7.25000000E+01	6.90912508E+01	5.15854041E+01	2.79556808E+01
	QSMODE	9.55635681E+00	9.59086509E+00	9.56010164E+00	9.56143490E+00	6.67287063E-03
	DQSMODE	9.55653826E+00	9.56804828E+00	9.56053841E+00	9.56031606E+00	2.96335342E-03
M47	DE	1.92077317E+01	2.19381566E+02	3.17631744E+01	4.43519673E+01	3.93282946E+01
	FA	1.59155920E+01	2.46690502E+02	2.69034384E+01	5.65600508E+01	6.61464425E+01
	TLBO	1.00213799E+01	2.59154247E+02	1.26707393E+01	4.17940299E+01	6.08545588E+01
	SA	2.96281165E+01	1.07099426E+02	5.51033574E+01	5.73347884E+01	2.12658481E+01
	GA	1.39768576E+01	8.21044379E+02	4.16581748E+01	1.26935490E+02	1.74008728E+02
	CMAES	2.53045114E+02	1.32284328E+03	8.33480809E+02	7.68658205E+02	1.95425660E+02
	PSO	2.30202263E+01	3.26459774E+03	3.53096389E+02	5.29107605E+02	6.02067891E+02
	BAS	5.45925931E+03	1.22415660E+04	7.83051166E+03	8.15752086E+03	1.56372965E+03
	ABC	1.66974463E+01	8.90878092E+01	4.91893827E+01	4.88746594E+01	2.15391264E+01
	WOA	1.08979217E+01	1.17626692E+02	1.28173888E+01	4.03265213E+01	3.99323092E+01
	MFO	3.22740129E+01	6.92210270E+02	2.19382806E+02	2.24842923E+02	1.92168108E+02
	GWO	1.01436710E+01	3.55111160E+02	1.57659542E+01	5.22031114E+01	8.50744997E+01
	HHO	1.31035715E+01	9.69714746E+01	1.69951533E+01	2.26567322E+01	1.83643497E+01
	CSOA	1.29348584E+01	3.67452637E+02	6.33909791E+01	9.37405546E+01	8.97986586E+01
	CSO	1.31832312E+01	1.20774623E+03	3.15019601E+01	2.01606847E+02	3.09339849E+02
	IMODEII	9.89556682E+00	6.99811943E+01	1.00651054E+01	1.59889791E+01	1.83052760E+01
	QSMODE	1.00788110E+01	1.00978584E+01	1.00841282E+01	1.00837129E+01	4.43308630E-03
	DQSMODE	1.00794162E+01	1.00890250E+01	1.00822537E+01	1.00834356E+01	3.47043337E-03
M48	DE	2.51463373E+01	3.52855504E+02	4.14968500E+01	7.29857660E+01	7.86837202E+01
	FA	2.09434675E+01	3.74313062E+02	3.63515179E+01	1.27649414E+02	1.20228364E+02
	TLBO	1.35423218E+01	5.36554905E+02	3.84949192E+01	1.11136287E+02	1.46333581E+02
	SA	3.06214446E+01	5.95476337E+02	3.75224058E+01	7.80039415E+01	1.22199193E+02
	GA	2.79851230E+01	4.06378793E+02	5.41625293E+01	1.39335875E+02	1.32470117E+02
	CMAES	5.20693513E+02	1.85490629E+03	6.83801913E+02	9.90366975E+02	4.75975431E+02
	PSO	3.87381780E+01	2.30430347E+03	1.19297523E+03	1.22373460E+03	5.61531063E+02
	BAS	1.11649313E+04	2.12822047E+04	1.55127712E+04	1.57488424E+04	2.69505914E+03
	ABC	2.58443800E+01	6.24388137E+01	3.91316192E+01	3.97892343E+01	9.81230395E+00
	WOA	1.35547277E+01	2.22551602E+02	2.22541331E+02	1.83428788E+02	6.16794867E+01
	MFO	3.93538146E+01	1.36692621E+03	3.50399012E+02	3.65098277E+02	2.62464202E+02
	GWO	1.35239770E+01	7.53266606E+02	5.03655194E+01	1.34442891E+02	1.73985533E+02
	HHO	2.08627497E+01	2.93196409E+02	1.69618641E+02	1.56720903E+02	6.21541232E+01
	CSOA	2.38199781E+01	4.61102692E+02	1.99108128E+02	2.07623341E+02	1.31158260E+02
	CSO	1.52100618E+01	2.43450201E+03	3.29115040E+02	5.83773039E+02	6.54874276E+02
	IMODEII	1.34759119E+01	1.35007845E+01	1.34759120E+01	1.34773039E+01	5.27960266E-03
	QSMODE	1.34841481E+01	1.34858471E+01	1.34851972E+01	1.34851111E+01	3.38446565E-04
	DQSMODE	1.34841370E+01	1.34853939E+01	1.34850390E+01	1.34849892E+01	3.06904004E-04

Table S3 (Cont.): Best, worst, median, mean, and SD Results of all the 18 algorithms across the 30 runs for the models (M49-M50).

M	Alg.	Best	Worst	Median	Mean	SD
M49	DE	1.67444254E+01	7.00412765E+01	3.21201093E+01	3.62492798E+01	1.44304182E+01
	FA	2.01288477E+01	4.10932332E+02	3.98923773E+01	8.10205346E+01	1.03888225E+02
	TLBO	1.94494146E+01	5.86392043E+02	5.94260506E+01	1.05877114E+02	1.19160575E+02
	SA	2.26010524E+01	1.14528052E+02	2.93500656E+01	3.95647175E+01	2.09994843E+01
	GA	2.06773975E+01	6.51015113E+02	4.80702785E+01	1.43574595E+02	1.83947698E+02
	CMAES	3.17900586E+02	2.51918904E+03	4.61583639E+02	7.08941582E+02	6.17713937E+02
	PSO	4.00356545E+02	3.64272799E+03	9.16988731E+02	1.11246923E+03	6.96948946E+02
	BAS	9.10865673E+03	1.99236494E+04	1.47200949E+04	1.46793967E+04	2.78654842E+03
	ABC	1.80075744E+01	9.15011776E+01	2.37622253E+01	2.93159874E+01	1.49731006E+01
	WOA	1.25151383E+01	6.12947823E+01	5.11141785E+01	4.78600824E+01	1.14034144E+01
	MFO	2.78924753E+01	1.44665794E+03	4.00994109E+02	4.56044552E+02	4.31744685E+02
	GWO	9.88084238E+00	4.96824705E+02	5.38603725E+01	1.11769744E+02	1.17439592E+02
	HHO	1.99862392E+01	9.85382242E+01	5.64299176E+01	5.13208086E+01	2.48805530E+01
	CSOA	2.06734105E+01	1.04588088E+03	2.12013146E+02	2.63160658E+02	2.13357229E+02
	CSO	1.59898916E+01	3.13943965E+03	8.03258908E+02	7.99161597E+02	7.15746315E+02
	IMODEII	9.82409021E+00	9.67536511E+01	5.19814919E+01	4.94830359E+01	1.93467222E+01
	QSMODE	9.95912586E+00	9.97545704E+00	9.96229923E+00	9.96374175E+00	3.99968896E-03
	DQSMODE	9.96006414E+00	9.97144532E+00	9.96196095E+00	9.96292068E+00	2.51360474E-03
M50	DE	2.10575107E+01	3.45026312E+02	3.96931046E+01	5.56398966E+01	5.72699706E+01
	FA	1.88749757E+01	5.55384810E+02	3.96989158E+01	8.80743878E+01	1.17308608E+02
	TLBO	1.39898640E+01	5.76066660E+02	7.29487516E+01	1.47022209E+02	1.53322810E+02
	SA	2.87520019E+01	2.13569456E+02	4.42819334E+01	4.83640851E+01	3.38921033E+01
	GA	2.18881172E+01	7.15819666E+02	1.05770357E+02	1.93855788E+02	1.73377314E+02
	CMAES	4.77459884E+02	4.90400304E+03	6.77676621E+02	1.05750407E+03	8.44255734E+02
	PSO	6.46901284E+02	3.85601741E+03	1.61997385E+03	1.86888141E+03	9.35568025E+02
	BAS	1.44119076E+04	2.41491714E+04	1.89909020E+04	1.86902920E+04	2.84660535E+03
	ABC	2.33539154E+01	8.15980590E+01	4.12415811E+01	4.37653476E+01	1.29680320E+01
	WOA	1.35298883E+01	8.36981726E+01	6.62106925E+01	6.05692648E+01	1.67528318E+01
	MFO	3.27929967E+01	2.58217207E+03	1.05525075E+02	3.04329578E+02	5.41957896E+02
	GWO	2.12540798E+01	4.12594982E+02	5.15059011E+01	1.21991574E+02	1.14798870E+02
	HHO	2.59295860E+01	8.03877515E+01	7.13965902E+01	7.06208705E+01	9.60176981E+00
	CSOA	2.99371943E+01	1.16910774E+03	5.03528061E+02	4.48568405E+02	2.51097286E+02
	CSO	4.05220307E+01	3.44852065E+03	1.62571766E+03	1.59718256E+03	8.90760078E+02
	IMODEII	1.14736850E+01	6.43854610E+01	6.32196830E+01	4.13499437E+01	2.62281698E+01
	QSMODE	1.15461859E+01	1.25496221E+01	1.20970174E+01	1.20490078E+01	1.92844090E-01
	DQSMODE	1.15136310E+01	1.25495052E+01	1.20965474E+01	1.21364833E+01	3.05363071E-01

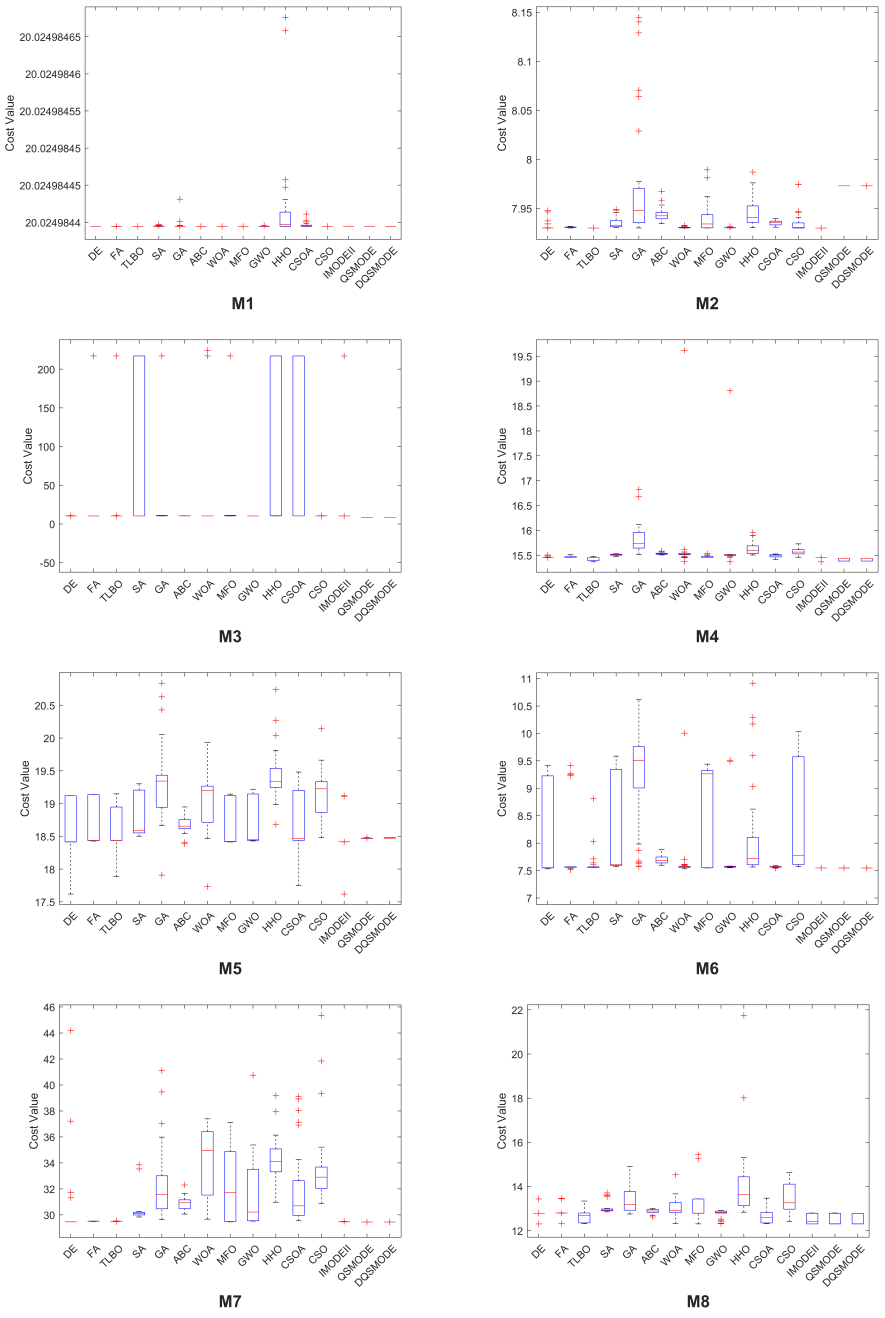


Figure S8: Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

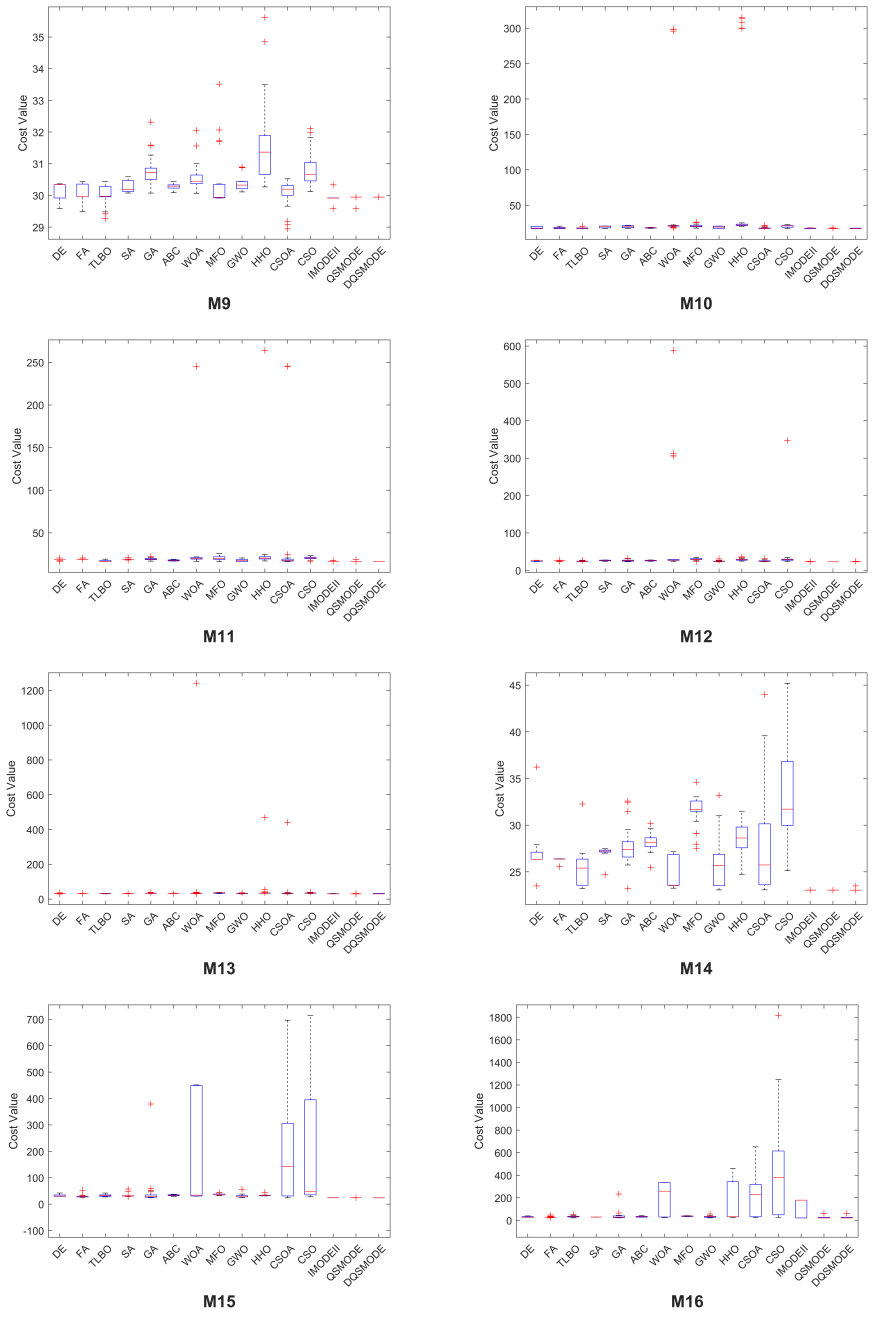


Figure S8 (Cont.): Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

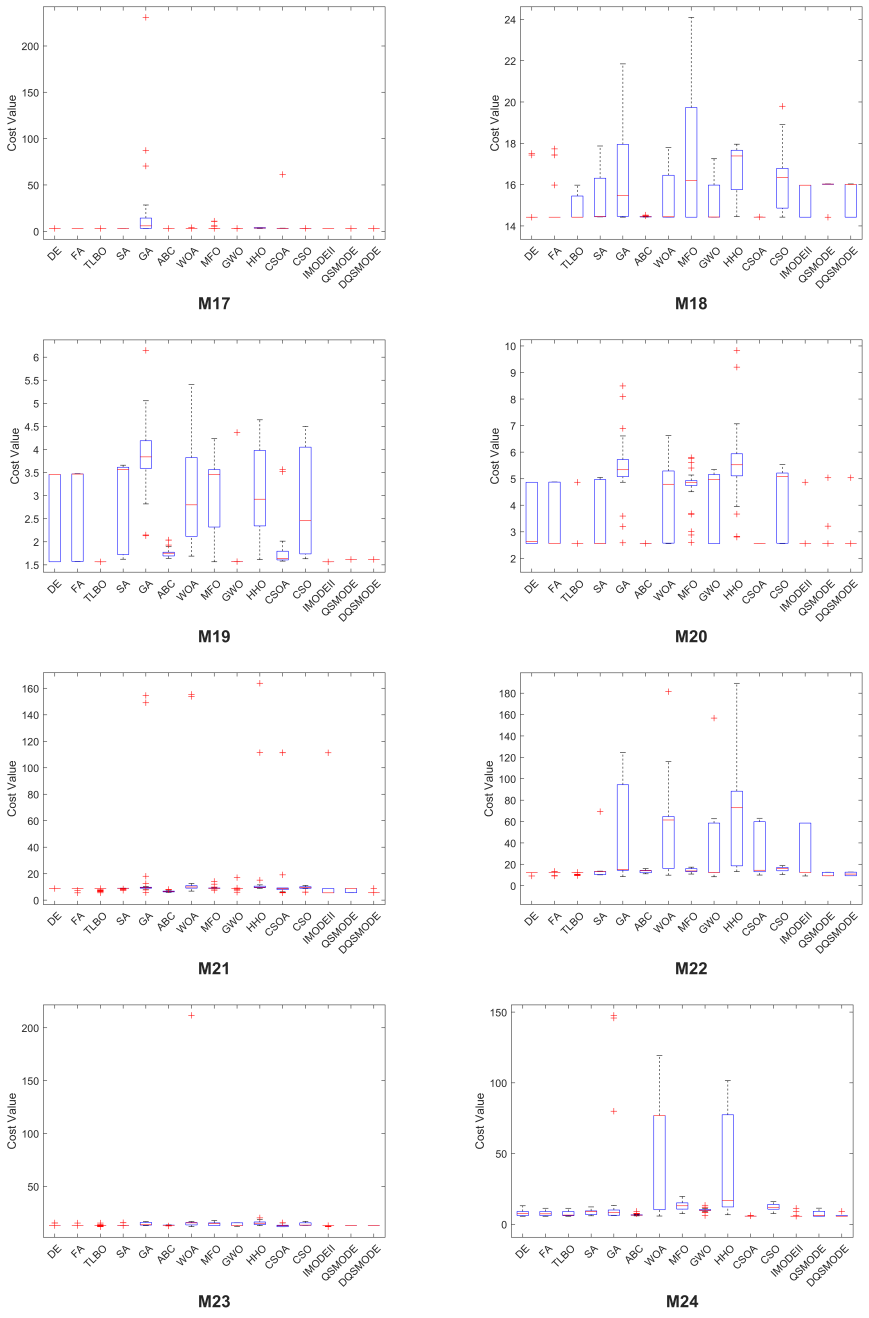


Figure S8 (Cont.): Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

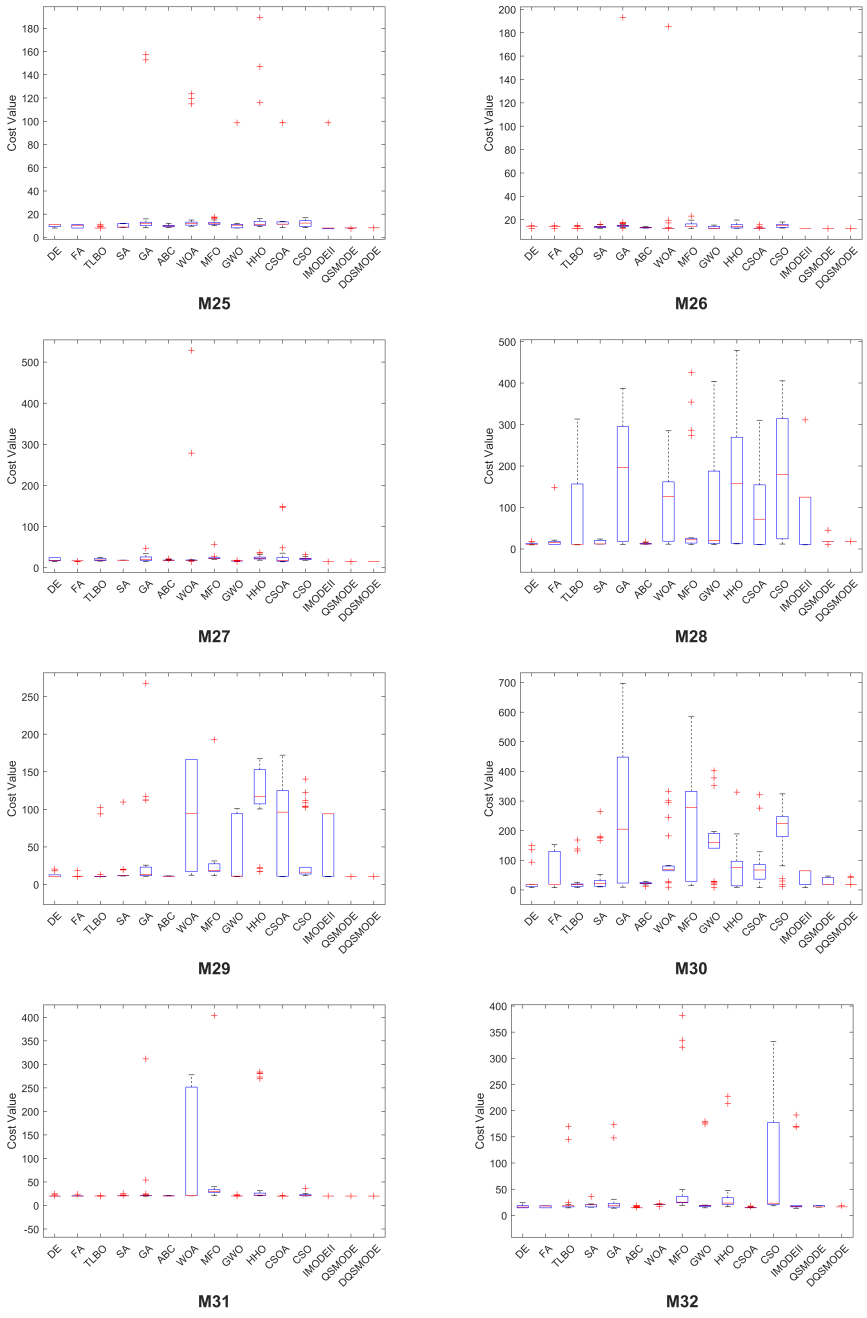


Figure S8 (Cont.): Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

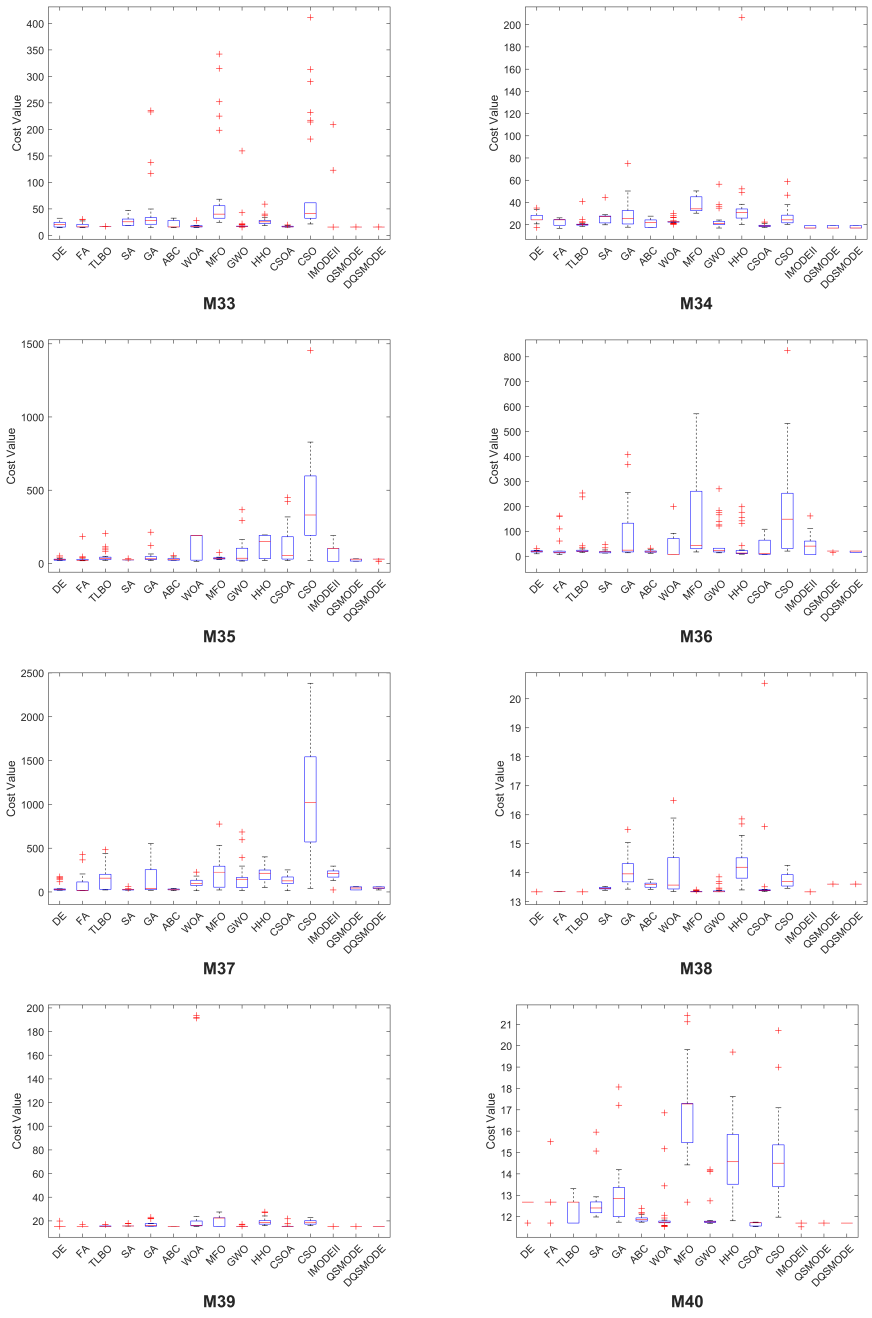


Figure S8 (Cont.): Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

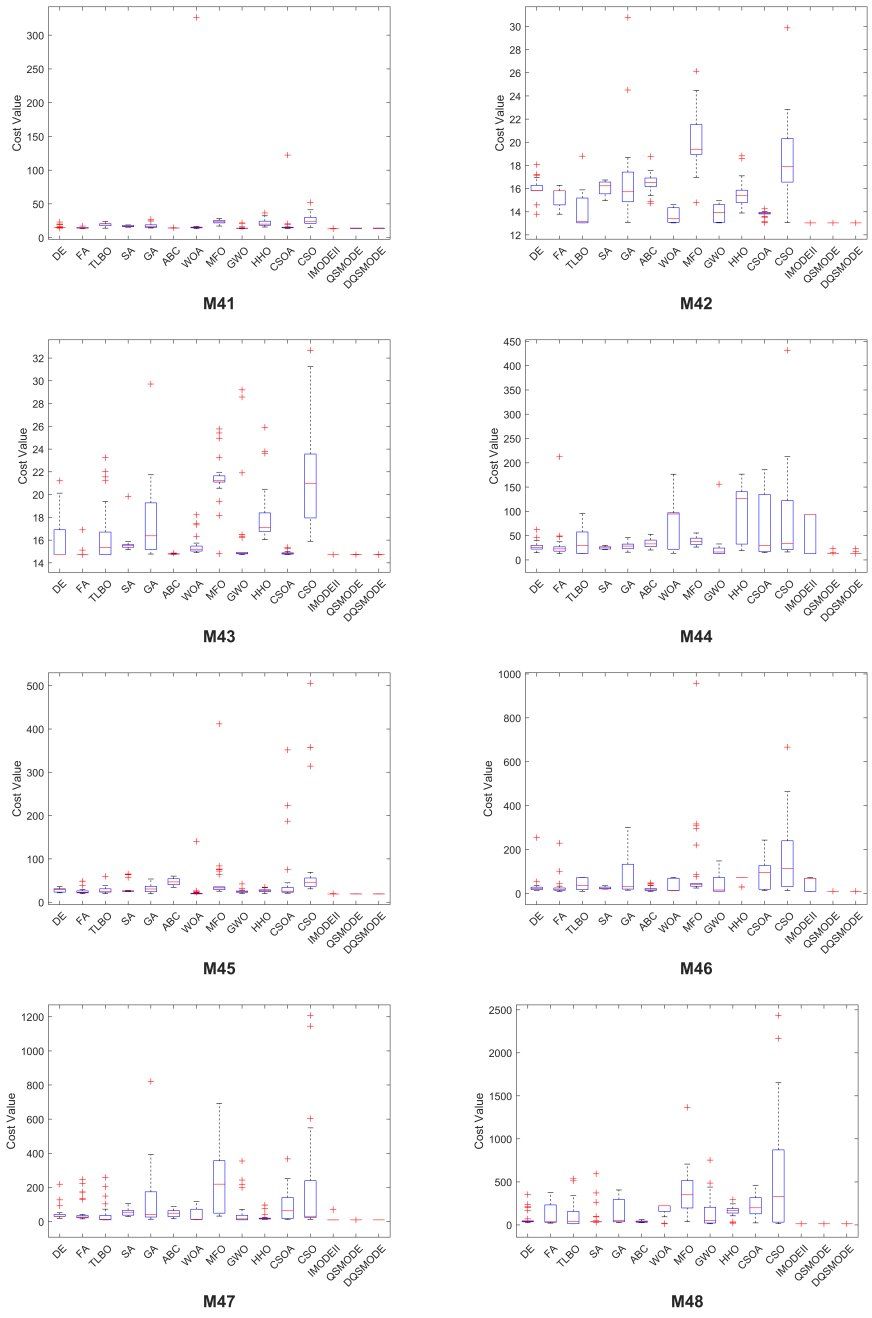


Figure S8 (Cont.): Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

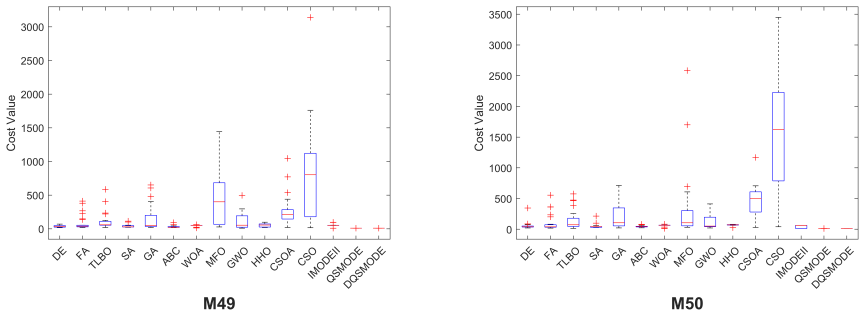


Figure S8 (Cont.): Box plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

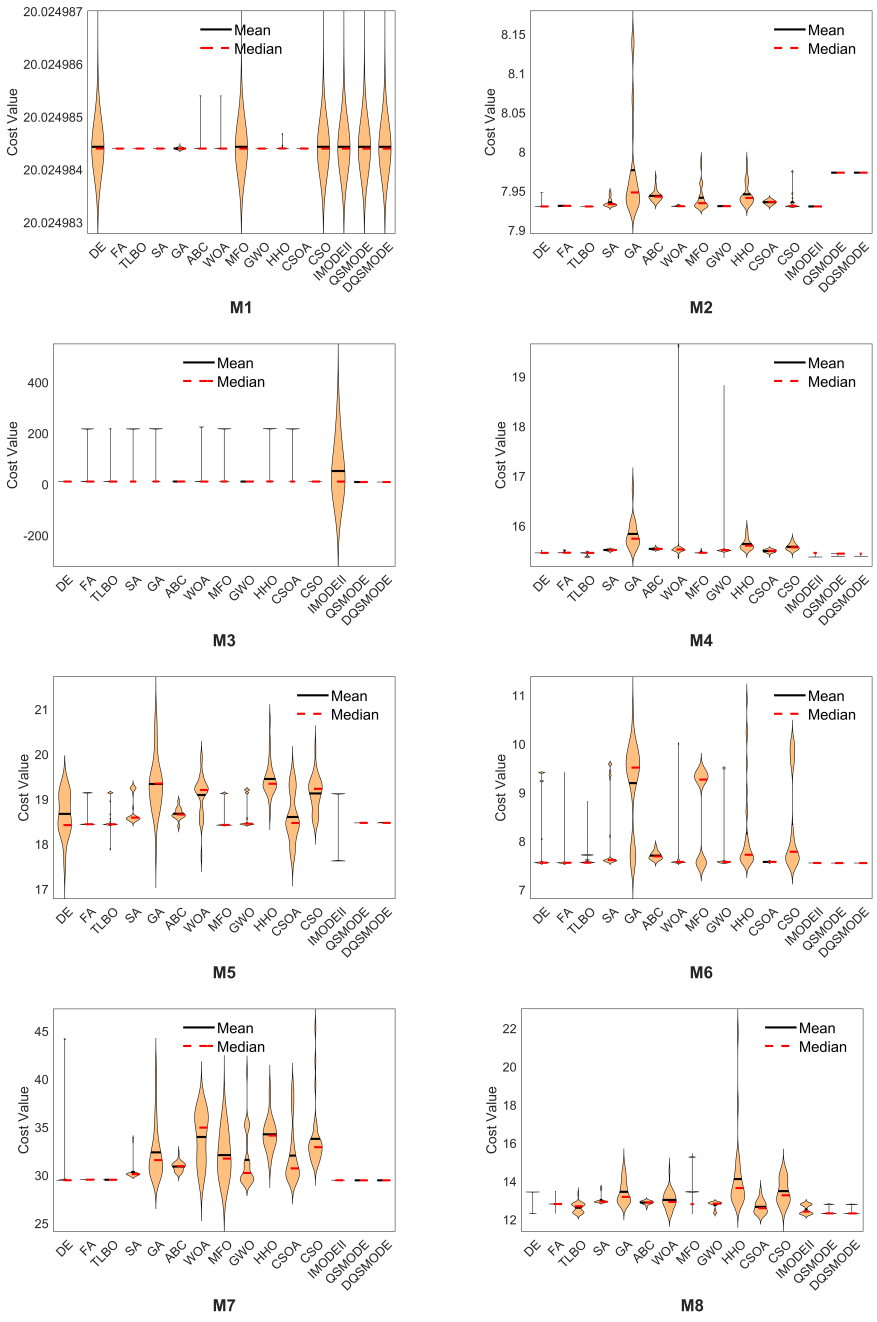


Figure S9: Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

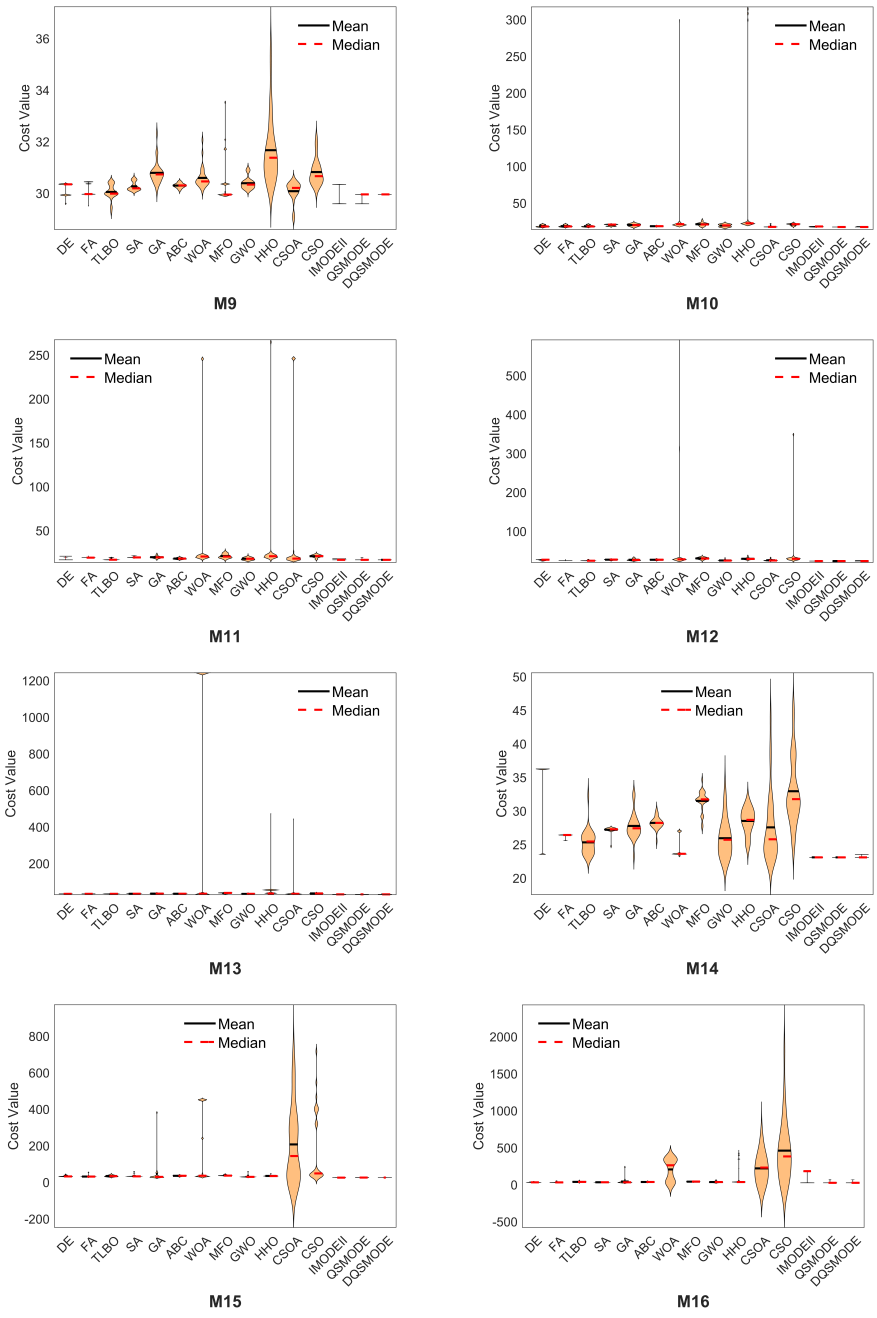


Figure S9 (Cont.): Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

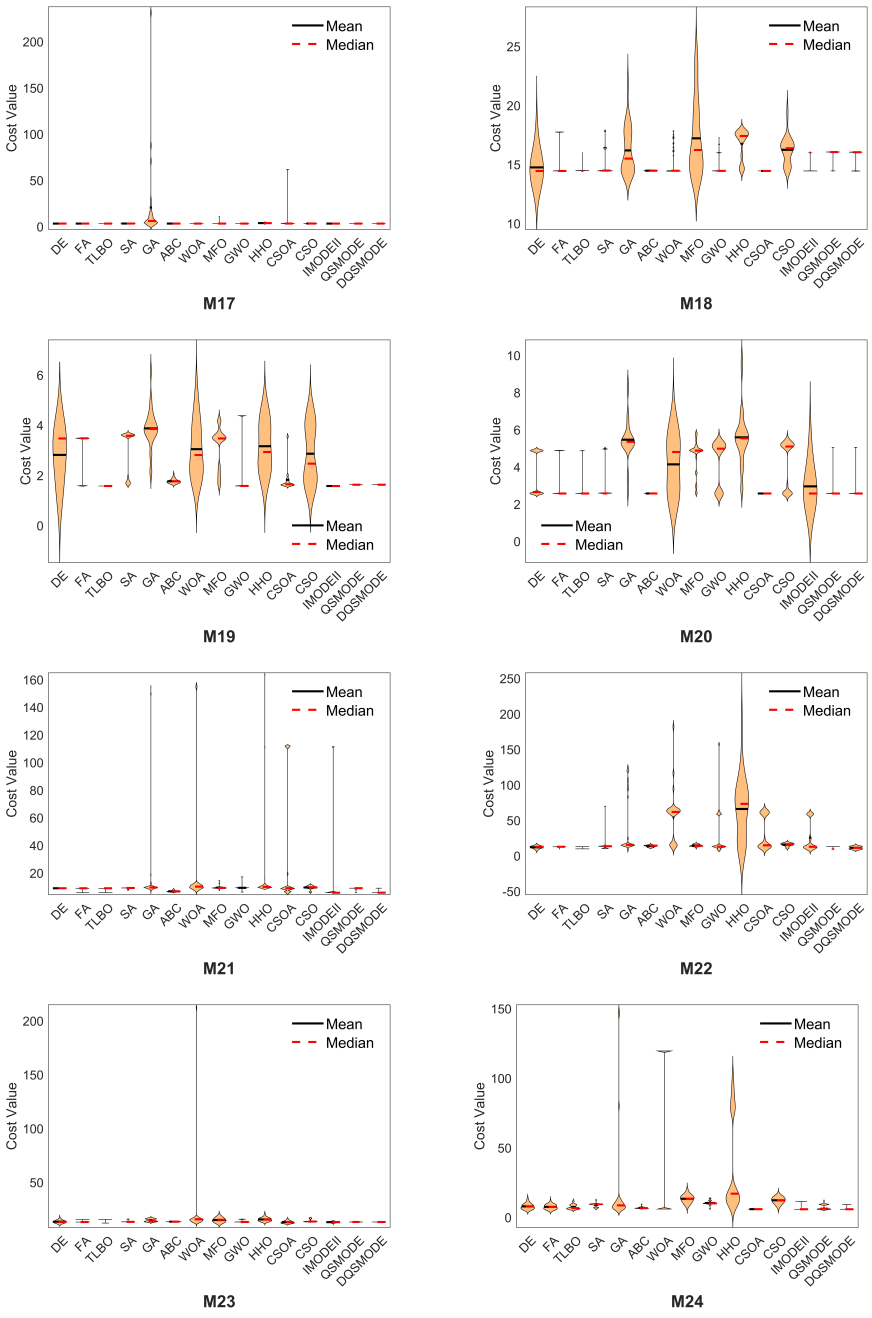


Figure S9 (Cont.): Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

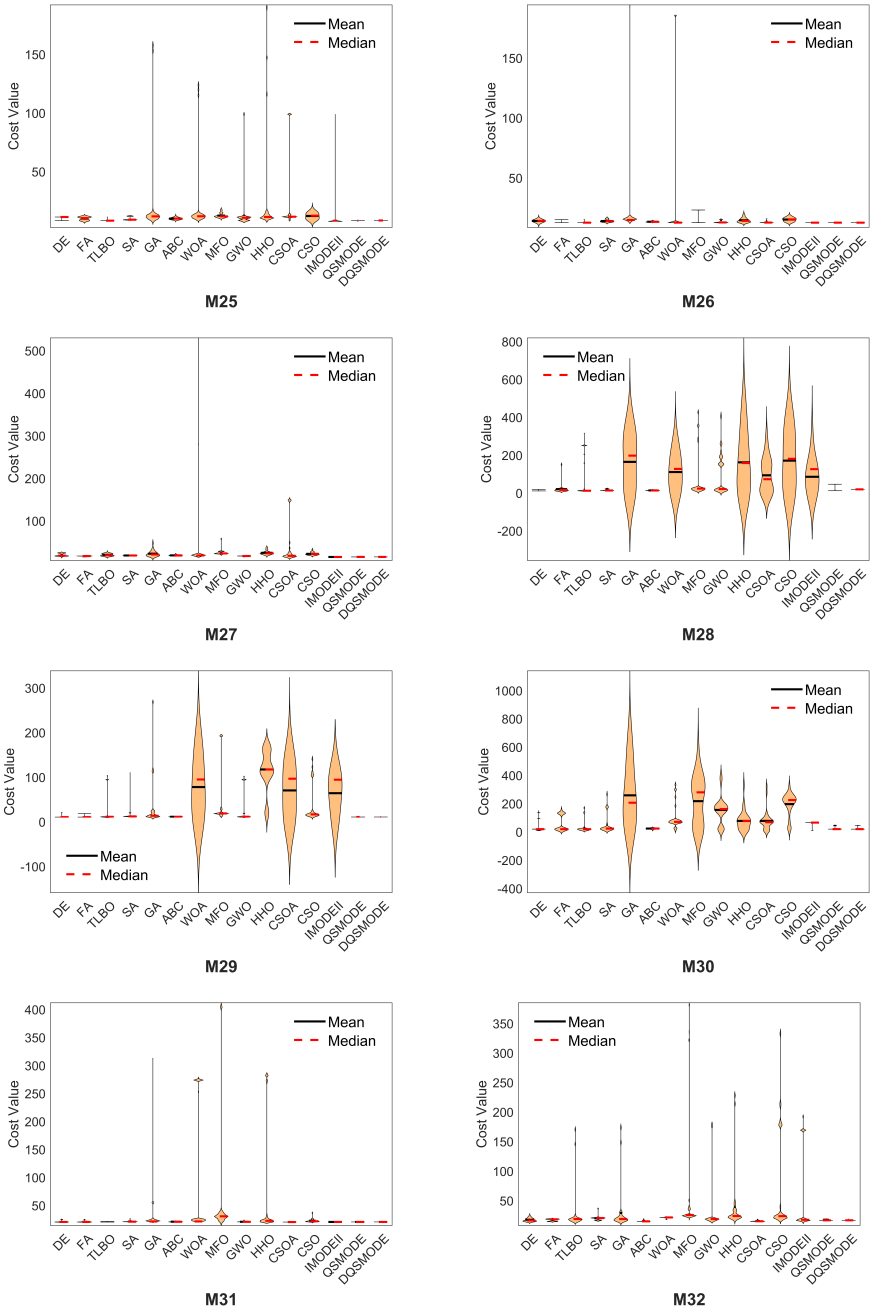


Figure S9 (Cont.): Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

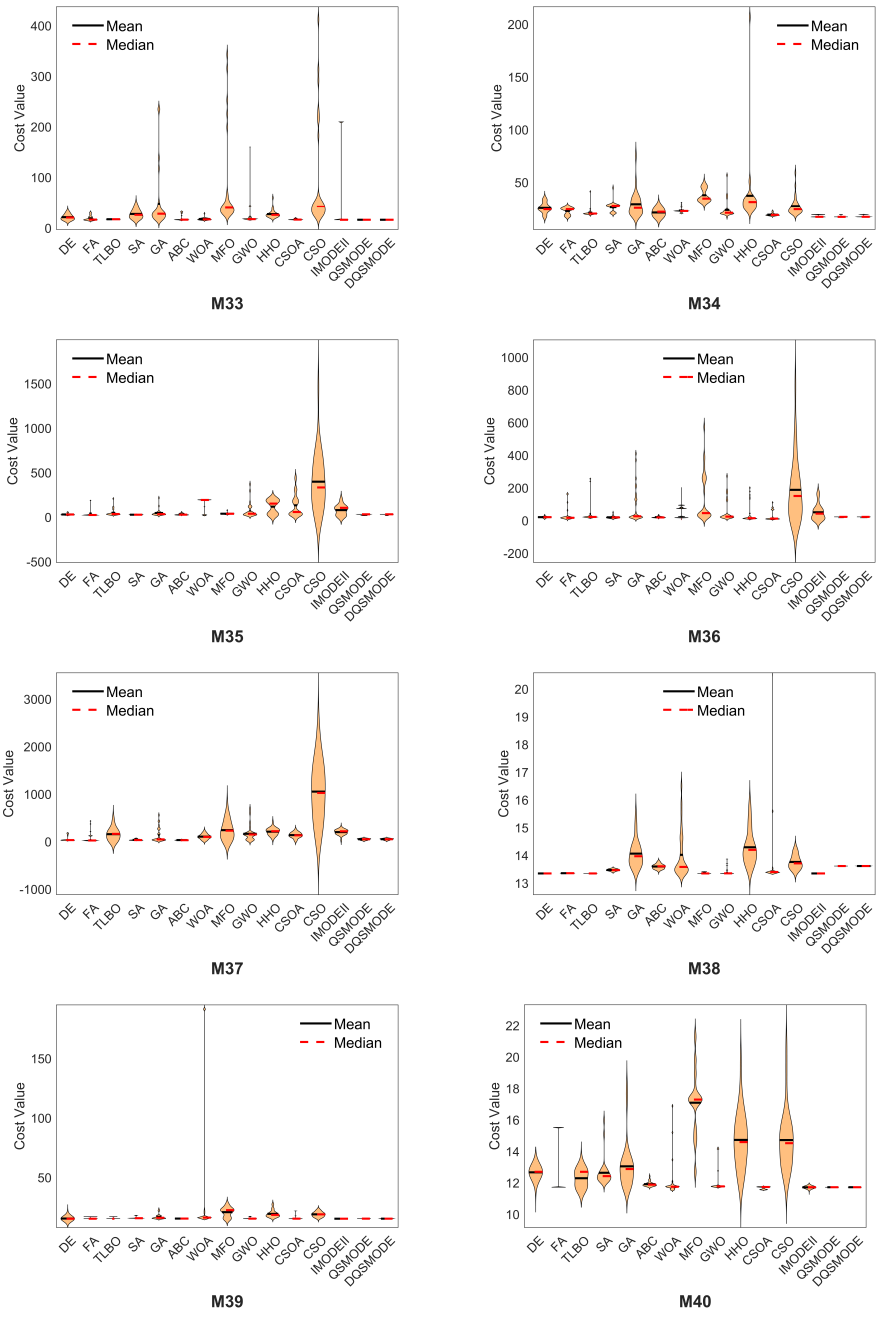


Figure S9 (Cont.): Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

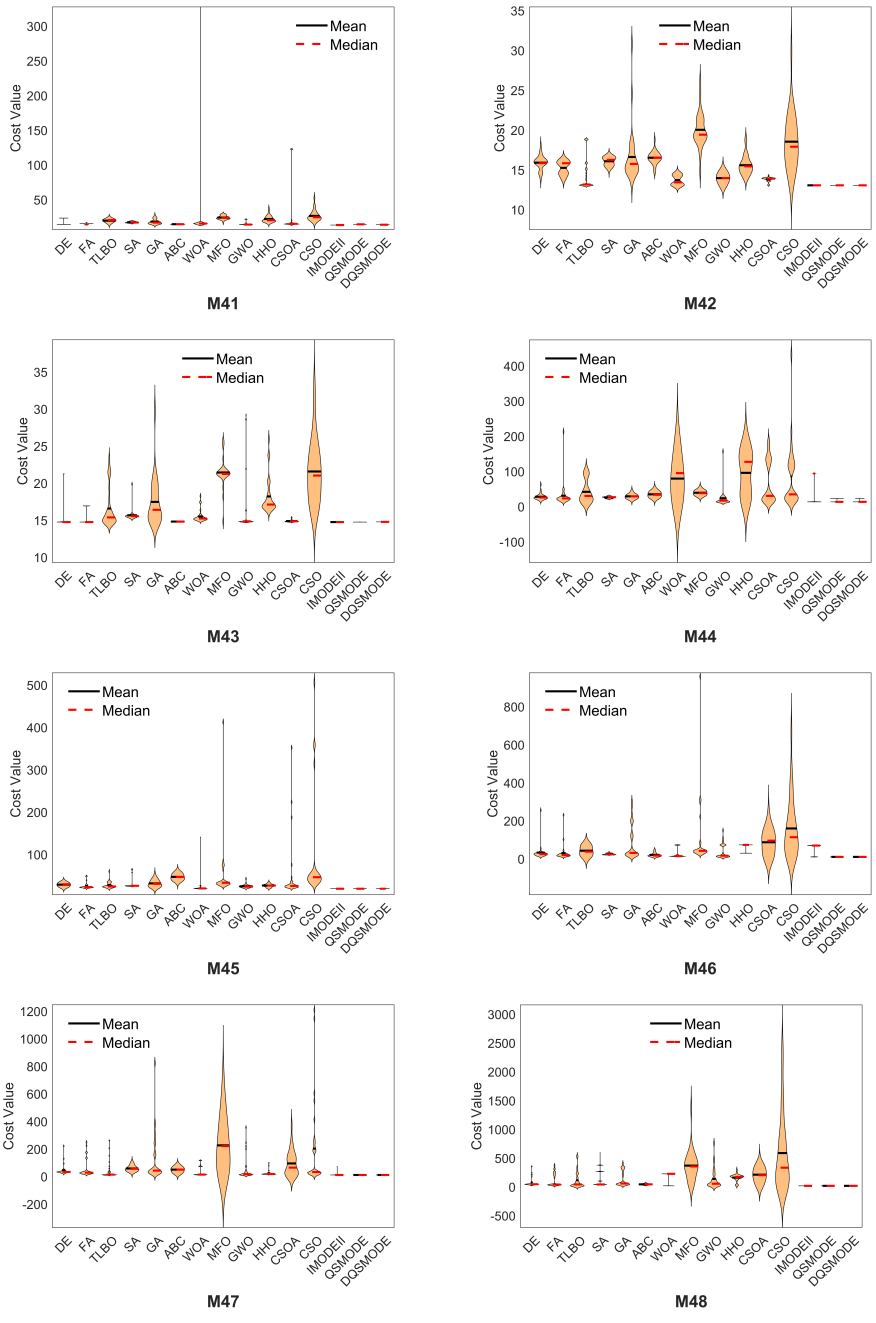


Figure S9 (Cont.): Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

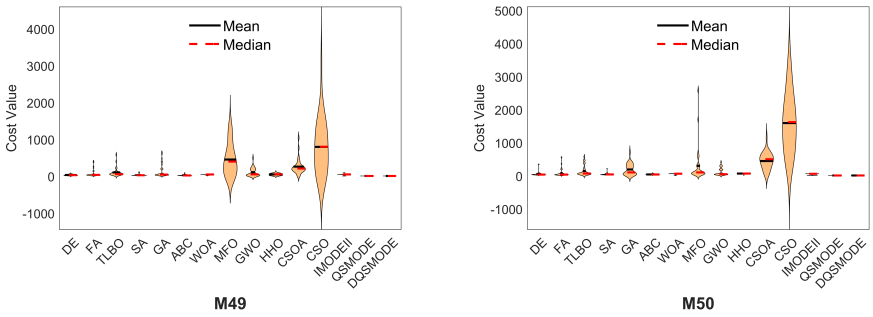


Figure S9 (Cont.): Violin plots for all the 18 meta-heuristic optimization algorithms in 30 runs for all models.

Table S4: Statistical Analysis of group comparison for all 50 models for all the 18 meta-heuristic optimization algorithms. In the Friedman test, the best algorithm is the one with the minimum mean rank. The significance level α is between 0.05 and 0.1. The results are significant if p-value $< \alpha$. In SNE-SR ranking test, SNE is the sum of normalized error, SR is the sum rank, the score is out of 100, and the best algorithm is the one with the highest score.

Alg.	Friedman Test			SNE-SR Ranking Test					
	sum rank	mean rank	rank	SNE	Score1	SR	Score2	Score	Rank
DE	323.5	6.47	6	22.4294	48.7623	323.5	20.9428	69.7051	6
FA	331	6.62	7	22.2901	49.0671	331	20.4683	69.5354	7
TLBO	309	6.18	4	22.0282	49.6505	309	21.9256	71.5761	4
SA	397	7.94	8	22.9821	47.5896	397	17.0655	64.6551	10
GA	611	12.22	13	22.5744	48.4491	611	11.0884	59.5375	12
CMAES	853	17.06	18	28.1953	38.7905	853	7.9426	46.7331	17
PSO	783.5	15.67	16	24.6396	44.3882	783.5	8.6471	53.0353	16
BAS	840	16.8	17	48.5775	22.5147	840	8.0655	30.5802	18
ABC	314	6.28	5	22.7234	48.1314	314	21.5764	69.7079	5
WOA	540	10.8	11	22.5093	48.5891	540	12.5463	61.1354	11
MFO	598.5	11.97	12	23.3522	46.8354	598.5	11.3200	58.1553	14
GWO	403	8.06	9	22.0647	49.5683	403	16.8114	66.3797	8
HHO	634	12.68	15	23.9575	45.6522	634	10.6861	56.3383	15
CSOA	445	8.9	10	22.0213	49.6661	445	15.2247	64.8908	9
CSO	633	12.66	14	22.9610	47.6333	633	10.7030	58.3363	13
IMODEII	243.5	4.87	3	21.8742	50.0000	243.5	27.8234	77.8234	3
QSMODE	155.5	3.11	2	22.1053	49.4772	155.5	43.5691	93.0463	2
DQSMODE	135.5	2.71	1	22.1903	49.2877	135.5	50.0000	99.2877	1
	p-val	2.12E-114							

Table S5: Detailed Wilcoxon test for all 50 models for all the 18 meta-heuristic optimization algorithms across all the five model categories: open-field, single-obstacle, multi-obstacles, narrow-passages, and maze-like. DQSMODE is the reference algorithm in all paired comparisons. '+' means the number of models in which the DQSMODE is better, and '=' means draw. R+ > R- means the DQSMODE is better. The significance level α is between 0.05 and 0.1. The results are significant if p-value $< \alpha$.

DQSMODE vs.	Open-Field	Single-Obst.	Multi-Obst.	Narrow-Passage	Maze-like	Total	R+	R-	p-val	H
DE	+0/=1/-0	+1/=0/-1	+13/=0/-0	+19/=0/-2	+12/=0/-1	+45/=1/-4	1158	67	5.76E-08	TRUE
FA	+1/=0/-0	+1/=0/-1	+13/=0/-0	+20/=0/-1	+12/=0/-1	+47/=0/-3	1242	33	5.37E-09	TRUE
TLBO	+1/=0/-0	+1/=0/-1	+13/=0/-0	+17/=0/-4	+12/=0/-1	+44/=0/-6	1208	67	3.65E-08	TRUE
SA	+1/=0/-0	+1/=0/-1	+13/=0/-0	+16/=0/-5	+12/=0/-1	+43/=0/-7	1162	113	4.12E-07	TRUE
GA	+1/=0/-0	+2/=0/-0	+13/=0/-0	+21/=0/-0	+13/=0/-0	+50/=0/-0	1275	0	7.56E-10	TRUE
CMAES	+1/=0/-0	+2/=0/-0	+13/=0/-0	+21/=0/-0	+13/=0/-0	+50/=0/-0	1275	0	7.56E-10	TRUE
PSO	+0/=1/-0	+1/=0/-1	+13/=0/-0	+21/=0/-0	+13/=0/-0	+48/=1/-1	1224	1	1.18E-09	TRUE
BAS	+1/=0/-0	+2/=0/-0	+13/=0/-0	+21/=0/-0	+13/=0/-0	+50/=0/-0	1275	0	7.56E-10	TRUE
ABC	+1/=0/-0	+1/=0/-1	+13/=0/-0	+16/=0/-5	+12/=0/-1	+43/=0/-7	1119	156	3.35E-06	TRUE
WOA	+1/=0/-0	+1/=0/-1	+13/=0/-0	+20/=0/-1	+13/=0/-0	+48/=0/-2	1267	8	1.23E-09	TRUE
MFO	+0/=1/-0	+1/=0/-1	+13/=0/-0	+21/=0/-0	+12/=0/-1	+47/=1/-2	1220	5	1.51E-09	TRUE
GWO	+1/=0/-0	+1/=0/-1	+13/=0/-0	+20/=0/-1	+12/=0/-1	+47/=0/-3	1253	22	2.82E-09	TRUE
HHO	+1/=0/-0	+1/=0/-1	+13/=0/-0	+21/=0/-0	+13/=0/-0	+49/=0/-1	1273	2	8.53E-10	TRUE
CSOA	+1/=0/-0	+1/=0/-1	+13/=0/-0	+15/=0/-6	+12/=0/-1	+42/=0/-8	1176	99	2.01E-07	TRUE
CSO	+1/=0/-0	+1/=0/-1	+13/=0/-0	+21/=0/-0	+13/=0/-0	+49/=0/-1	1224	51	1.18E-09	TRUE
IMODEII	+0/=1/-0	+1/=0/-1	+10/=0/-3	+13/=0/-8	+5/=0/-8	+29/=1/-20	899	326	4.37E-03	TRUE
QSMODE	+0/=1/-0	+0/=0/-2	+6/=0/-7	+13/=0/-8	+12/=0/-1	+31/=1/-18	707	518	2.22E-01	FALSE

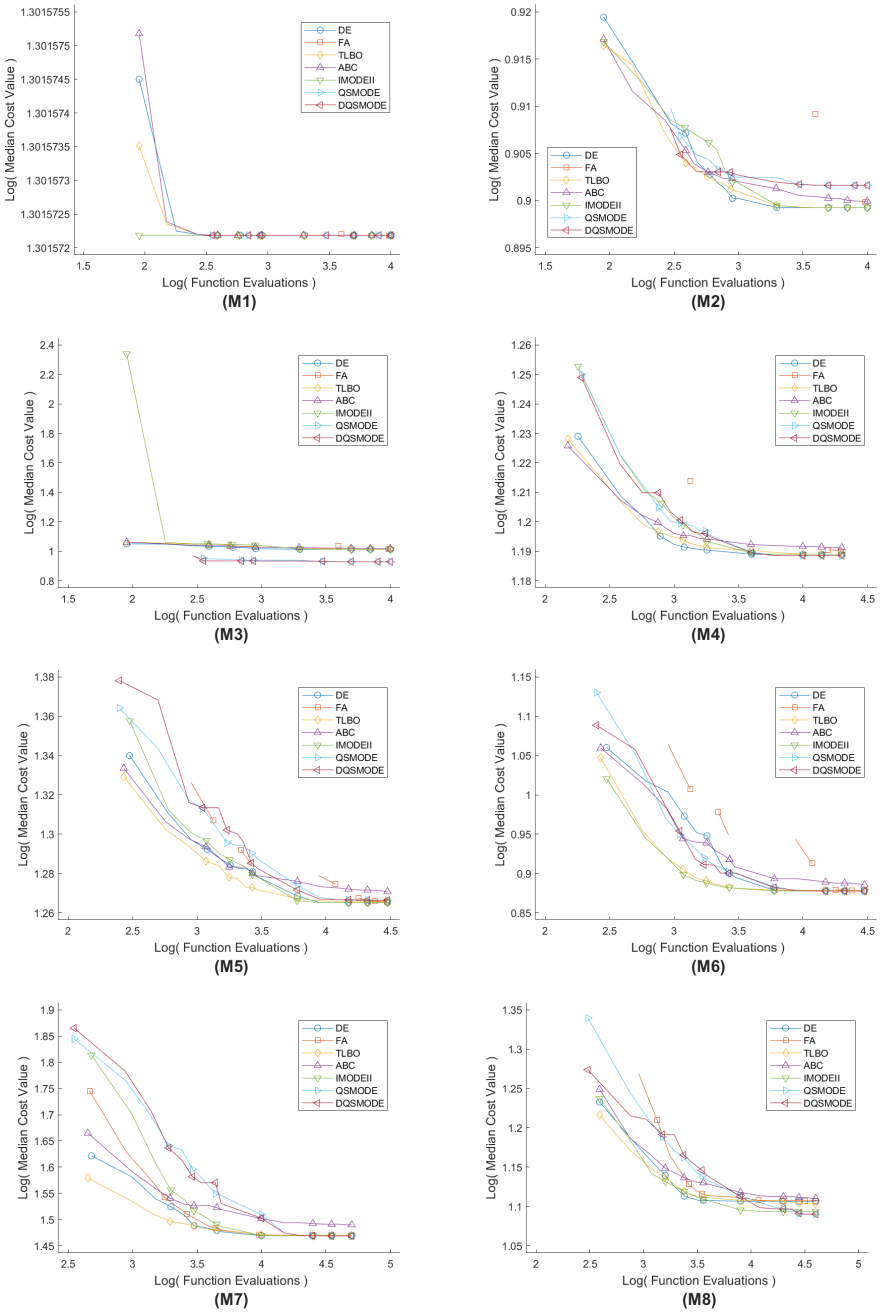


Figure S10: Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

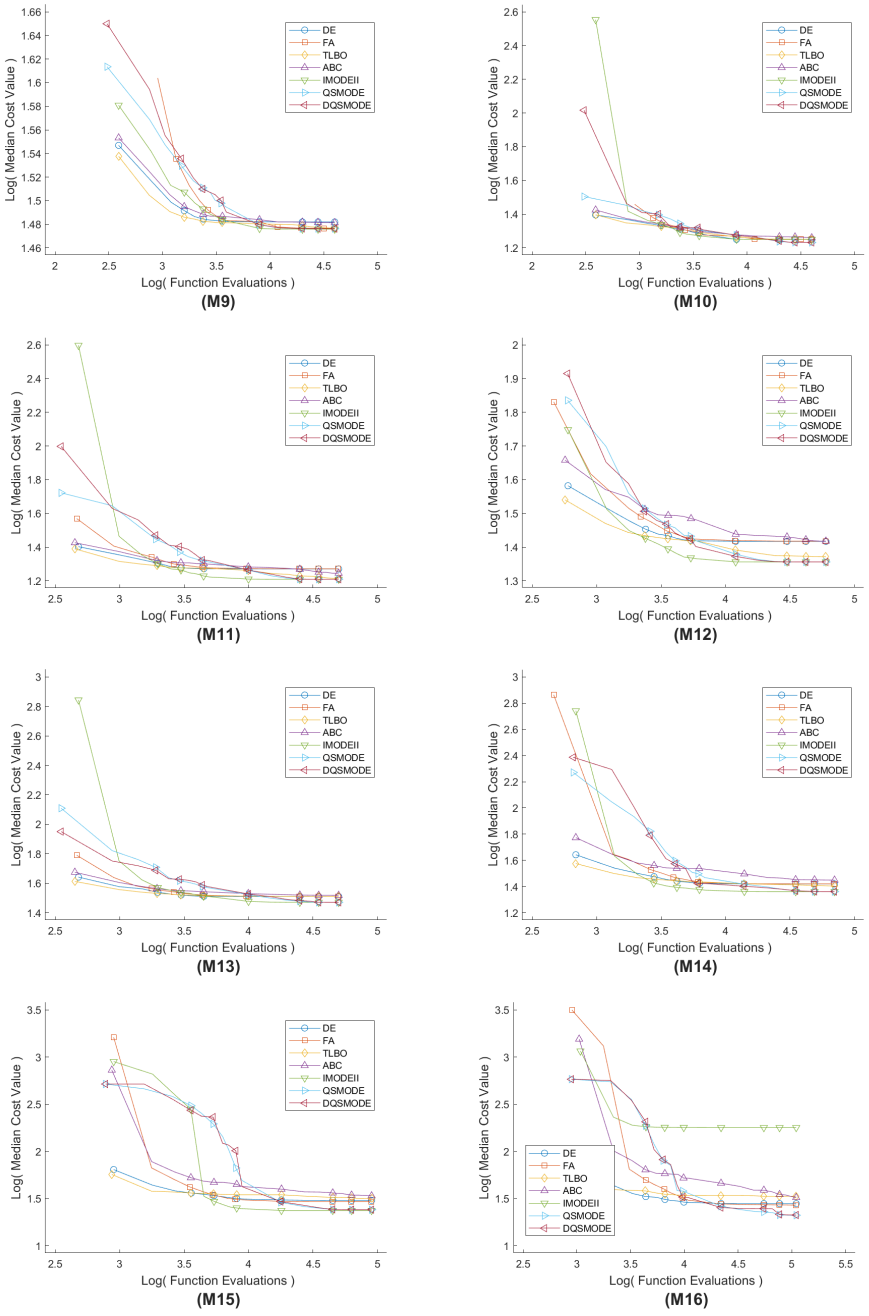


Figure S10 (Cont.): Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

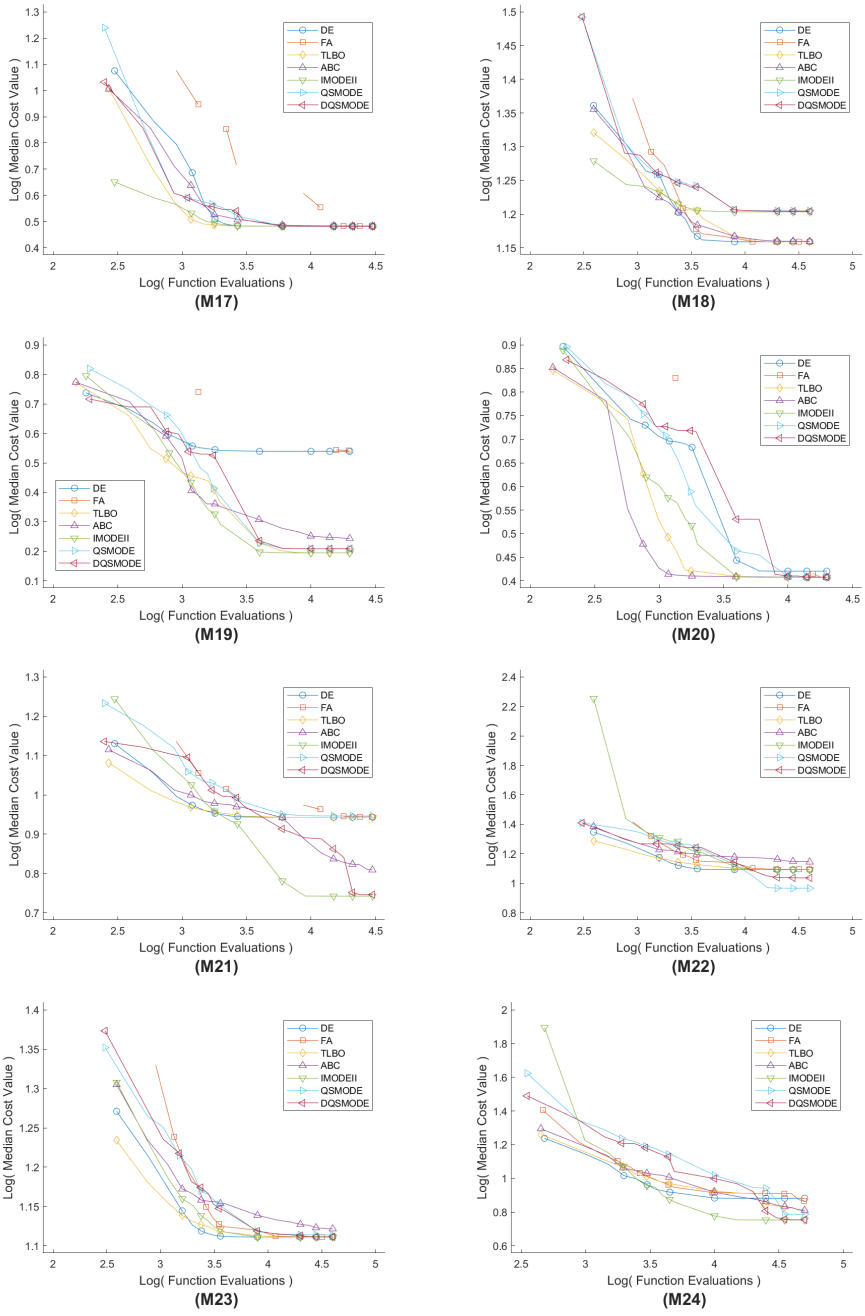


Figure S10 (Cont.): Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

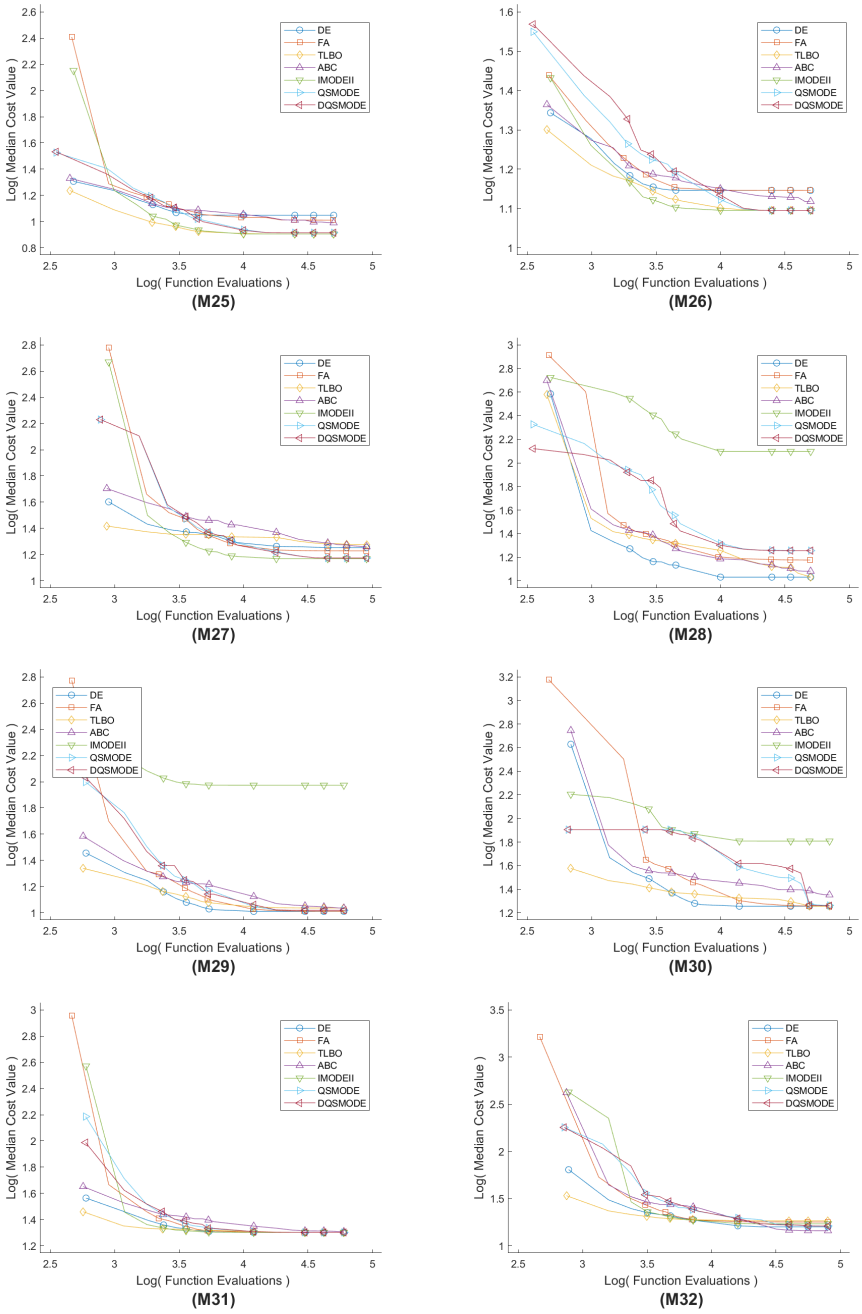


Figure S10 (Cont.): Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

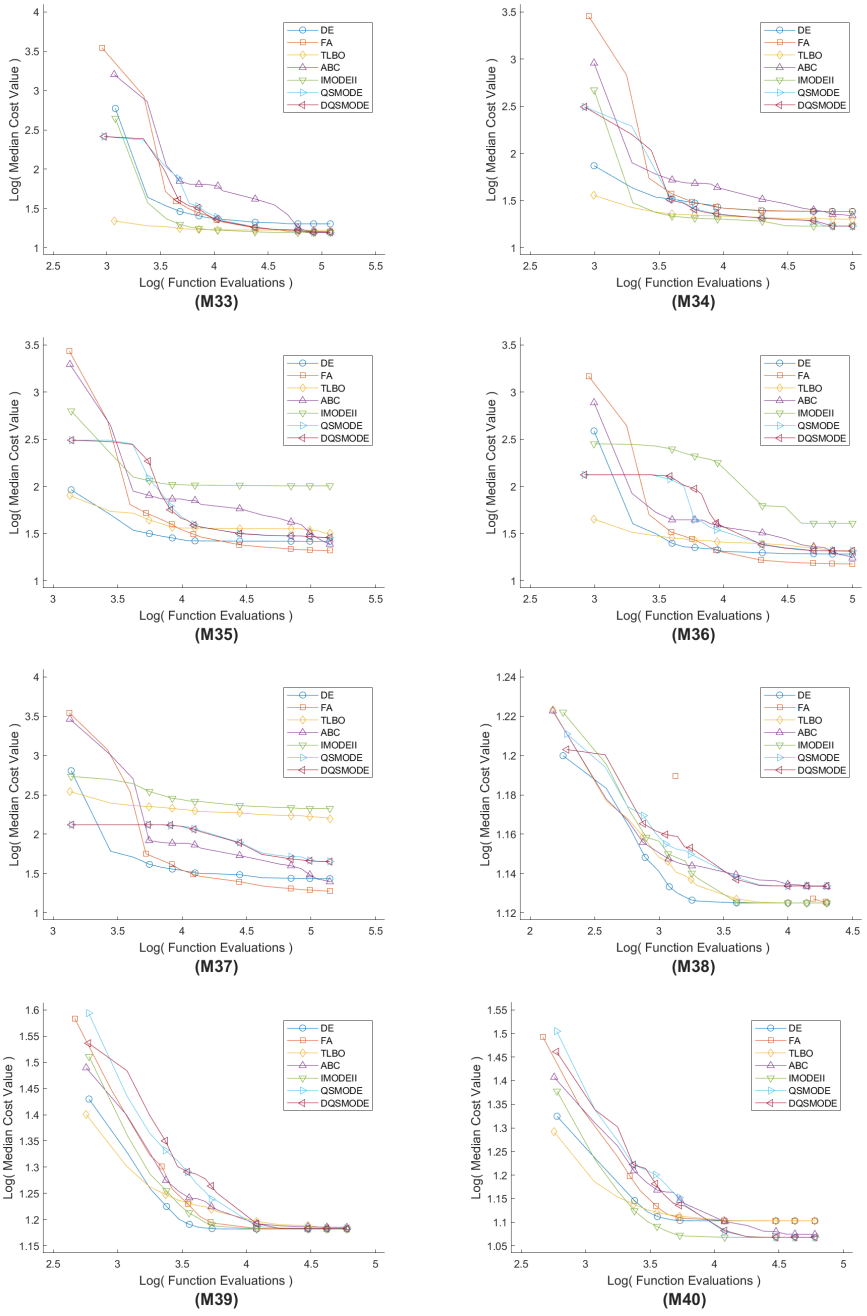


Figure S10 (Cont.): Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

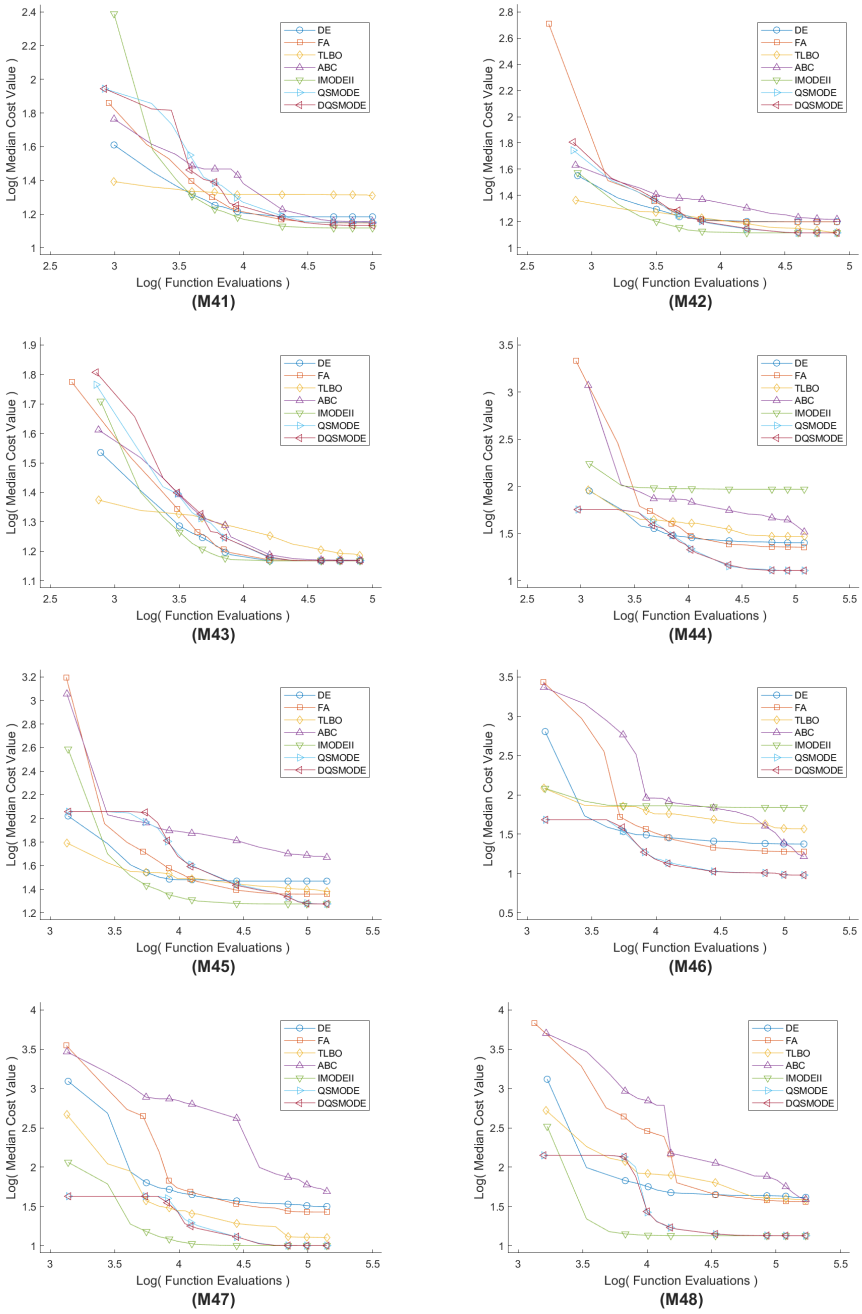


Figure S10 (Cont.): Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

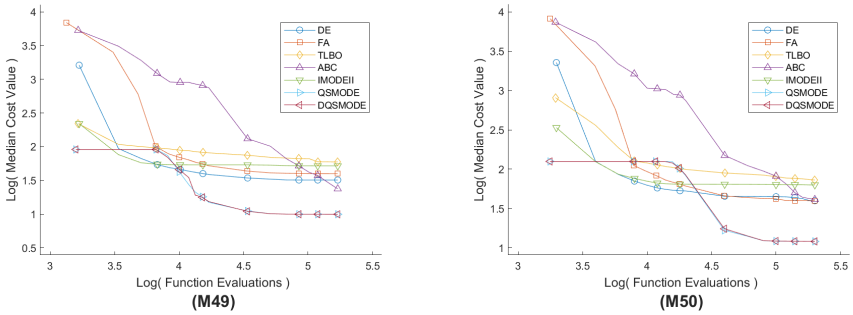


Figure S10 (Cont.): Convergence plots for top seven meta-heuristic optimization algorithms for the median cost in 30 runs for all models.

S5 Complete results of the 8 path-planning algorithms

Table S6: Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M1-M6).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M1	A*	2.0300E+01	2.0300E+01	2.0300E+01	2.0300E+01	0.0000E+00	100	136
	Dijkstra	2.0435E+01	2.0435E+01	2.0435E+01	2.0435E+01	0.0000E+00	100	136
	RRT	2.0025E+01	2.0190E+01	2.0069E+01	2.0082E+01	5.1071E-02	100	30
	RRT*	2.0025E+01	2.0172E+01	2.0070E+01	2.0072E+01	3.5834E-02	100	28
	APF	2.0025E+01	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	50	0
	DWA	2.1142E+01	2.1142E+01	2.1142E+01	2.1142E+01	0.0000E+00	100	272
	QSMODE	2.0025E+01	2.0025E+01	2.0025E+01	2.0025E+01	3.6134E-15	100	3
	DQSMODE	2.0025E+01	2.0025E+01	2.0025E+01	2.0025E+01	3.6134E-15	100	3
M2	A*	2.6009E+01	2.6009E+01	2.6009E+01	2.6009E+01	0.0000E+00	100	51
	Dijkstra	8.4184E+00	8.4184E+00	8.4184E+00	8.4184E+00	3.6134E-15	100	51
	RRT	8.2839E+00	9.0132E+00	8.6798E+00	8.6626E+00	1.8888E-01	100	27
	RRT*	8.3357E+00	9.4256E+00	8.5515E+00	8.6152E+00	2.2360E-01	100	26
	APF	8.3080E+00	8.7234E+00	8.3102E+00	8.3243E+00	7.5417E-02	100	5
	DWA	8.1865E+00	8.1865E+00	8.1865E+00	8.1865E+00	0.0000E+00	100	142
	QSMODE	7.9730E+00	7.9730E+00	7.9730E+00	7.9730E+00	3.9686E-15	100	3
	DQSMODE	7.9730E+00	7.9730E+00	7.9730E+00	7.9730E+00	3.4240E-15	100	3
M3	A*	2.7965E+01	2.7965E+01	2.7965E+01	2.7965E+01	1.4454E-14	100	54
	Dijkstra	9.1790E+00	9.1790E+00	9.1790E+00	9.1790E+00	3.6134E-15	100	54
	RRT	9.1590E+00	1.0276E+01	9.5369E+00	9.6222E+00	2.9048E-01	100	26
	RRT*	9.1135E+00	1.0150E+01	9.4409E+00	9.5068E+00	2.2860E-01	100	28
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	8.7416E+00	8.7416E+00	8.7416E+00	8.7416E+00	5.4202E-15	100	148
	QSMODE	8.5079E+00	8.5079E+00	8.5079E+00	8.5079E+00	2.5551E-15	100	3
	DQSMODE	8.5079E+00	8.5079E+00	8.5079E+00	8.5079E+00	3.1096E-14	100	3
M4	A*	1.6539E+01	1.6539E+01	1.6539E+01	1.6539E+01	0.0000E+00	100	92
	Dijkstra	1.6341E+01	1.6341E+01	1.6341E+01	1.6341E+01	3.6134E-15	100	92
	RRT	1.6645E+01	1.9097E+01	1.7348E+01	1.7399E+01	5.0115E-01	100	36
	RRT*	1.6501E+01	1.9940E+01	1.7376E+01	1.7509E+01	6.9512E-01	100	32
	APF	1.5696E+01	6.5535E+04	1.5701E+01	6.5535E+04	0.0000E+00	80	0
	DWA	1.6008E+01	1.6008E+01	1.6008E+01	1.6008E+01	1.0840E-14	100	232
	QSMODE	1.5385E+01	1.5438E+01	1.5438E+01	1.5420E+01	2.5450E-02	100	4
	DQSMODE	1.5385E+01	1.5438E+01	1.5438E+01	1.5416E+01	2.6452E-02	100	4
M5	A*	1.9052E+01	1.9052E+01	1.9052E+01	1.9052E+01	0.0000E+00	100	102
	Dijkstra	1.8728E+01	1.8728E+01	1.8728E+01	1.8728E+01	1.0840E-14	100	102
	RRT	1.8602E+01	2.1331E+01	1.9551E+01	1.9609E+01	5.7591E-01	100	35
	RRT*	1.8733E+01	2.2235E+01	1.9454E+01	1.9716E+01	8.6374E-01	100	31
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.7749E+01	1.7749E+01	1.7749E+01	1.7749E+01	7.2269E-15	100	238
	QSMODE	1.8468E+01	1.8481E+01	1.8468E+01	1.8470E+01	4.2700E-03	100	5
	DQSMODE	1.8468E+01	1.8481E+01	1.8468E+01	1.8472E+01	6.1041E-03	100	5
M6	A*	8.5183E+00	8.5183E+00	8.5183E+00	8.5183E+00	3.6134E-15	100	49
	Dijkstra	8.1548E+00	8.1548E+00	8.1548E+00	8.1548E+00	7.2269E-15	100	48
	RRT	7.9663E+00	1.1413E+01	8.4128E+00	8.6406E+00	7.6128E-01	100	26
	RRT*	7.8609E+00	9.4911E+00	8.4030E+00	8.4250E+00	3.6022E-01	100	25
	APF	1.0093E+01	6.5535E+04	1.0103E+01	6.5535E+04	0.0000E+00	90	0
	DWA	7.7717E+00	7.7717E+00	7.7717E+00	7.7717E+00	5.4202E-15	100	142
	QSMODE	7.5461E+00	7.5472E+00	7.5461E+00	7.5463E+00	4.0701E-04	100	5
	DQSMODE	7.5461E+00	7.5471E+00	7.5461E+00	7.5462E+00	2.4269E-04	100	5

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M7-M13).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M7	A*	6.0553E+01	6.0553E+01	6.0553E+01	6.0553E+01	3.6134E-14	100	155
	Dijkstra	2.9954E+01	2.9954E+01	2.9954E+01	2.9954E+01	1.4454E-14	100	155
	RRT	3.0943E+01	4.0820E+01	3.3021E+01	3.4233E+01	2.6922E+00	100	41
	RRT*	3.1352E+01	3.8783E+01	3.2656E+01	3.3102E+01	1.6351E+00	100	40
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.9658E+01	2.9658E+01	2.9658E+01	2.9658E+01	1.0840E-14	100	357
	QSMODE	2.9453E+01	2.9453E+01	2.9453E+01	2.9453E+01	1.4696E-05	100	7
	DQSMODE	2.9453E+01	2.9453E+01	2.9453E+01	2.9453E+01	5.7245E-06	100	7
M8	A*	1.3298E+01	1.3298E+01	1.3298E+01	1.3298E+01	0.0000E+00	100	70
	Dijkstra	1.2958E+01	1.2958E+01	1.2958E+01	1.2958E+01	9.0336E-15	100	70
	RRT	1.2623E+01	1.4052E+01	1.3176E+01	1.3163E+01	3.5754E-01	100	27
	RRT*	1.2885E+01	1.4625E+01	1.3219E+01	1.3358E+01	3.9619E-01	100	28
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.2472E+01	1.2472E+01	1.2472E+01	1.2472E+01	5.4202E-15	100	185
	QSMODE	1.2303E+01	1.2799E+01	1.2313E+01	1.2500E+01	2.3935E-01	100	6
	DQSMODE	1.2303E+01	1.2785E+01	1.2311E+01	1.2513E+01	2.4154E-01	100	6
M9	A*	3.0121E+01	3.0121E+01	3.0121E+01	3.0121E+01	2.1681E-14	100	157
	Dijkstra	3.0129E+01	3.0129E+01	3.0129E+01	3.0129E+01	1.0840E-14	100	157
	RRT	3.1045E+01	3.7572E+01	3.3918E+01	3.3997E+01	1.5706E+00	100	44
	RRT*	3.0055E+01	3.7313E+01	3.3420E+01	3.3503E+01	1.8295E+00	100	39
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.9655E+01	2.9655E+01	2.9655E+01	2.9655E+01	1.0840E-14	100	360
	QSMODE	2.9581E+01	2.9947E+01	2.9947E+01	2.9922E+01	9.2817E-02	100	6
	DQSMODE	2.9947E+01	2.9947E+01	2.9947E+01	2.9947E+01	1.8927E-04	100	6
M10	A*	1.8234E+01	1.8234E+01	1.8234E+01	1.8234E+01	7.2269E-15	100	101
	Dijkstra	1.8167E+01	1.8167E+01	1.8167E+01	1.8167E+01	7.2269E-15	100	101
	RRT	1.8251E+01	2.1174E+01	1.9344E+01	1.9465E+01	8.2300E-01	100	37
	RRT*	1.8018E+01	2.3531E+01	1.9323E+01	1.9831E+01	1.3960E+00	100	34
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.7883E+01	1.7883E+01	1.7883E+01	1.7883E+01	7.2269E-15	100	239
	QSMODE	1.7068E+01	1.8132E+01	1.7068E+01	1.7258E+01	3.5803E-01	100	6
	DQSMODE	1.7068E+01	1.7783E+01	1.7068E+01	1.7353E+01	3.5563E-01	100	6
M11	A*	1.8067E+01	1.8067E+01	1.8067E+01	1.8067E+01	1.4454E-14	100	98
	Dijkstra	1.7519E+01	1.7519E+01	1.7519E+01	1.7519E+01	7.2269E-15	100	98
	RRT	1.7022E+01	1.8309E+01	1.7509E+01	1.7572E+01	3.5341E-01	100	34
	RRT*	1.6793E+01	1.9311E+01	1.7725E+01	1.7809E+01	5.3589E-01	100	31
	APF	1.6547E+01	1.6777E+01	1.6551E+01	1.6576E+01	6.8439E-02	100	6
	DWA	1.6347E+01	1.6347E+01	1.6347E+01	1.6347E+01	7.2269E-15	100	224
	QSMODE	1.6215E+01	1.8660E+01	1.6216E+01	1.6379E+01	6.1998E-01	100	7
	DQSMODE	1.6215E+01	1.6216E+01	1.6216E+01	1.6216E+01	1.9833E-04	100	7
M12	A*	7.0318E+01	7.0318E+01	7.0318E+01	7.0318E+01	1.4454E-14	100	119
	Dijkstra	2.3506E+01	2.3506E+01	2.3506E+01	2.3506E+01	7.2269E-15	100	119
	RRT	2.3185E+01	2.5703E+01	2.4040E+01	2.4246E+01	7.3689E-01	100	34
	RRT*	2.3118E+01	2.6754E+01	2.4059E+01	2.4261E+01	8.5494E-01	100	32
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.3293E+01	2.3293E+01	2.3293E+01	2.3293E+01	1.0840E-14	100	293
	QSMODE	2.2715E+01	2.2715E+01	2.2715E+01	2.2715E+01	1.0501E-04	100	8
	DQSMODE	2.2715E+01	2.4067E+01	2.2715E+01	2.2760E+01	2.4695E-01	100	8
M13	A*	3.0698E+01	3.0698E+01	3.0698E+01	3.0698E+01	1.0840E-14	100	168
	Dijkstra	3.1096E+01	3.1096E+01	3.1096E+01	3.1096E+01	1.4454E-14	100	168
	RRT	3.1766E+01	3.9615E+01	3.3626E+01	3.4121E+01	1.9114E+00	100	44
	RRT*	3.1564E+01	4.1590E+01	3.3578E+01	3.4521E+01	2.7155E+00	100	40
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	3.0073E+01	3.0073E+01	3.0073E+01	3.0073E+01	1.4454E-14	100	364
	QSMODE	2.9606E+01	3.2427E+01	2.9607E+01	2.9849E+01	7.4482E-01	100	7
	DQSMODE	2.9606E+01	3.2427E+01	2.9608E+01	3.0503E+01	1.3043E+00	100	7

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M14-M20).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M14	A*	2.4205E+01	2.4205E+01	2.4205E+01	2.4205E+01	1.8067E-14	100	125
	Dijkstra	2.4033E+01	2.4033E+01	2.4033E+01	2.4033E+01	1.0840E-14	100	125
	RRT	2.3282E+01	3.0835E+01	2.4915E+01	2.5148E+01	1.3671E+00	100	33
	RRT*	2.3992E+01	2.6348E+01	2.5222E+01	2.5176E+01	5.5626E-01	100	32
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.3546E+01	2.3546E+01	2.3546E+01	2.3546E+01	7.2269E-15	100	296
	QSMODE	2.3044E+01	2.3050E+01	2.3045E+01	2.3045E+01	1.1873E-03	100	9
	DQSMODE	2.3044E+01	2.3494E+01	2.3045E+01	2.3105E+01	1.5536E-01	100	9
M15	A*	2.4878E+01	2.4878E+01	2.4878E+01	2.4878E+01	7.2269E-15	100	130
	Dijkstra	2.4878E+01	2.4878E+01	2.4878E+01	2.4878E+01	7.2269E-15	100	130
	RRT	2.4545E+01	3.2846E+01	2.6714E+01	2.7234E+01	1.7505E+00	100	38
	RRT*	2.4422E+01	2.9554E+01	2.6199E+01	2.6370E+01	1.2998E+00	100	34
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.4769E+01	2.4769E+01	2.4769E+01	2.4769E+01	0.0000E+00	100	309
	QSMODE	2.3735E+01	2.4177E+01	2.4175E+01	2.4131E+01	1.3429E-01	100	11
	DQSMODE	2.3734E+01	2.4176E+01	2.4175E+01	2.3999E+01	2.1932E-01	100	11
M16	A*	2.3061E+01	2.3061E+01	2.3061E+01	2.3061E+01	3.6134E-15	100	125
	Dijkstra	2.2575E+01	2.2575E+01	2.2575E+01	2.2575E+01	1.0840E-14	100	125
	RRT	2.3194E+01	2.6145E+01	2.4393E+01	2.4494E+01	8.8568E-01	100	38
	RRT*	2.3028E+01	2.6758E+01	2.3894E+01	2.4189E+01	9.8882E-01	100	35
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.1654E+01	2.1654E+01	2.1654E+01	2.1654E+01	1.0840E-14	100	279
	QSMODE	2.1109E+01	6.2222E+01	2.1112E+01	3.1244E+01	1.7238E+01	100	13
	DQSMODE	2.1109E+01	6.1741E+01	2.1231E+01	2.4267E+01	7.5058E+00	100	13
M17	A*	3.6094E+00	3.6094E+00	3.6094E+00	3.6094E+00	1.8067E-15	100	23
	Dijkstra	3.4728E+00	3.4728E+00	3.4728E+00	3.4728E+00	2.2584E-15	100	23
	RRT	3.1852E+00	4.5391E+00	3.4652E+00	3.5260E+00	3.1827E-01	100	13
	RRT*	3.1826E+00	4.2980E+00	3.4010E+00	3.4333E+00	2.2195E-01	100	12
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	3.4633E+00	3.4633E+00	3.4633E+00	3.4633E+00	2.2584E-15	100	110
	QSMODE	3.0374E+00	3.0374E+00	3.0374E+00	3.0374E+00	1.6813E-09	100	5
	DQSMODE	3.0374E+00	3.0374E+00	3.0374E+00	3.0374E+00	3.3149E-10	100	5
M18	A*	1.5512E+01	1.5512E+01	1.5512E+01	1.5512E+01	3.6134E-15	100	93
	Dijkstra	1.5600E+01	1.5600E+01	1.5600E+01	1.5600E+01	1.2647E-14	100	93
	RRT	1.4629E+01	1.8216E+01	1.5338E+01	1.5582E+01	7.7667E-01	100	25
	RRT*	1.4684E+01	1.7392E+01	1.5288E+01	1.5474E+01	6.6718E-01	100	29
	APF	1.4626E+01	6.5535E+04	1.4630E+01	6.5535E+04	0.0000E+00	86.67	0
	DWA	1.5164E+01	1.5164E+01	1.5164E+01	1.5164E+01	7.2269E-15	100	214
	QSMODE	1.4424E+01	1.6037E+01	1.6026E+01	1.5758E+01	6.0683E-01	100	6
	DQSMODE	1.4424E+01	1.6032E+01	1.6012E+01	1.5593E+01	7.1668E-01	100	6
M19	A*	4.2237E+00	4.2237E+00	4.2237E+00	4.2237E+00	2.7101E-15	100	29
	Dijkstra	4.1243E+00	4.1243E+00	4.1243E+00	4.1243E+00	1.8067E-15	100	29
	RRT	1.9257E+00	1.0602E+01	7.4277E+00	7.0237E+00	2.7156E+00	100	21
	RRT*	2.2667E+00	2.1009E+01	6.8585E+00	7.3960E+00	2.9904E+00	100	20
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	1.6173E+00	1.6176E+00	1.6173E+00	1.6174E+00	7.7094E-05	100	4
	DQSMODE	1.6173E+00	1.6176E+00	1.6173E+00	1.6173E+00	4.0486E-05	100	4
M20	A*	5.6806E+00	5.6806E+00	5.6806E+00	5.6806E+00	0.0000E+00	100	36
	Dijkstra	5.5589E+00	5.5589E+00	5.5589E+00	5.5589E+00	1.8067E-15	100	36
	RRT	2.5676E+00	6.5975E+00	2.6942E+00	2.9546E+00	8.8215E-01	100	15
	RRT*	2.5645E+00	1.1108E+01	2.7387E+00	3.4660E+00	1.9048E+00	100	15
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.7385E+00	2.7385E+00	2.7385E+00	2.7385E+00	1.3550E-15	100	104
	QSMODE	2.5576E+00	5.0361E+00	2.5576E+00	2.8272E+00	7.5812E-01	100	4
	DQSMODE	2.5576E+00	5.0354E+00	2.5576E+00	2.8879E+00	8.5664E-01	100	4

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M21-M27).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M21	A*	6.1895E+00	6.1895E+00	6.1895E+00	6.1895E+00	9.0336E-16	100	35
	Dijkstra	5.9680E+00	5.9680E+00	5.9680E+00	5.9680E+00	2.7101E-15	100	35
	RRT	6.2617E+00	1.3449E+01	9.6977E+00	9.6174E+00	2.1291E+00	100	22
	RRT*	6.2521E+00	1.5015E+01	1.0017E+01	9.6966E+00	2.2286E+00	100	21
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	5.5768E+00	8.8472E+00	8.8363E+00	7.8439E+00	1.4373E+00	100	5
	DQSMODE	5.5768E+00	8.8452E+00	5.5768E+00	6.1216E+00	1.2388E+00	100	5
M22	A*	1.3559E+01	1.3559E+01	1.3559E+01	1.3559E+01	0.0000E+00	100	90
	Dijkstra	1.3535E+01	1.3535E+01	1.3535E+01	1.3535E+01	7.2269E-15	100	90
	RRT	1.1722E+01	2.5494E+01	1.7459E+01	1.8102E+01	4.5834E+00	100	41
	RRT*	1.1176E+01	2.8931E+01	1.4993E+01	1.6871E+01	4.8108E+00	100	32
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	9.2303E+00	1.2625E+01	9.2725E+00	1.0248E+01	1.5223E+00	100	6
	DQSMODE	9.2684E+00	1.2797E+01	1.0891E+01	1.0970E+01	1.7318E+00	100	6
M23	A*	1.5073E+01	1.5073E+01	1.5073E+01	1.5073E+01	7.2269E-15	100	78
	Dijkstra	1.3276E+01	1.3276E+01	1.3276E+01	1.3276E+01	0.0000E+00	100	78
	RRT	1.2212E+01	1.9501E+01	1.3309E+01	1.3740E+01	1.4972E+00	100	30
	RRT*	1.2486E+01	1.8064E+01	1.3751E+01	1.3929E+01	1.2140E+00	100	29
	APF	1.3602E+01	1.3874E+01	1.3604E+01	1.3616E+01	5.0977E-02	100	5
	DWA	1.2466E+01	1.2466E+01	1.2466E+01	1.2466E+01	3.6134E-15	100	185
	QSMODE	1.2930E+01	1.3007E+01	1.2988E+01	1.2970E+01	3.7742E-02	100	6
	DQSMODE	1.2930E+01	1.3007E+01	1.2930E+01	1.2964E+01	3.8510E-02	100	6
M24	A*	9.6797E+00	9.6797E+00	9.6797E+00	9.6797E+00	5.4202E-15	100	57
	Dijkstra	9.3684E+00	9.3684E+00	9.3684E+00	9.3684E+00	5.4202E-15	100	57
	RRT	6.5702E+00	1.4112E+01	8.0821E+00	8.4255E+00	1.5137E+00	100	22
	RRT*	6.9228E+00	1.6520E+01	9.0256E+00	9.4102E+00	2.1409E+00	100	26
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	5.6736E+00	1.1389E+01	6.1231E+00	7.2153E+00	1.8078E+00	100	7
	DQSMODE	5.6837E+00	9.1828E+00	5.6842E+00	6.4458E+00	1.4006E+00	100	7
M25	A*	8.8270E+00	8.8270E+00	8.8270E+00	8.8270E+00	5.4202E-15	100	50
	Dijkstra	8.5287E+00	8.5287E+00	8.5287E+00	8.5287E+00	5.4202E-15	100	50
	RRT	8.7694E+00	2.4068E+01	1.2390E+01	1.2465E+01	3.2527E+00	100	30
	RRT*	9.0139E+00	1.7111E+01	1.2420E+01	1.2322E+01	2.4596E+00	100	25
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	7.4453E+00	8.2358E+00	8.2354E+00	8.1707E+00	1.4936E-01	100	7
	DQSMODE	8.2329E+00	8.2358E+00	8.2358E+00	8.2353E+00	9.7899E-04	100	7
M26	A*	1.3106E+01	1.3106E+01	1.3106E+01	1.3106E+01	5.4202E-15	100	75
	Dijkstra	1.3012E+01	1.3012E+01	1.3012E+01	1.3012E+01	5.4202E-15	100	75
	RRT	1.2900E+01	1.3959E+01	1.3312E+01	1.3329E+01	2.7252E-01	100	29
	RRT*	1.2826E+01	1.3739E+01	1.3239E+01	1.3228E+01	2.2984E-01	100	27
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.2608E+01	1.2608E+01	1.2608E+01	1.2608E+01	5.4202E-15	100	189
	QSMODE	1.2458E+01	1.2458E+01	1.2458E+01	1.2458E+01	4.7399E-06	100	7
	DQSMODE	1.2458E+01	1.2458E+01	1.2458E+01	1.2458E+01	1.0154E-08	100	7
M27	A*	1.6125E+01	1.6125E+01	1.6125E+01	1.6125E+01	3.6134E-15	100	90
	Dijkstra	1.5987E+01	1.5987E+01	1.5987E+01	1.5987E+01	5.4202E-15	100	90
	RRT	1.5718E+01	1.9339E+01	1.6769E+01	1.6821E+01	7.7142E-01	100	35
	RRT*	1.5783E+01	1.8826E+01	1.6714E+01	1.6924E+01	7.7982E-01	100	32
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.5627E+01	1.5627E+01	1.5627E+01	1.5627E+01	1.0840E-14	100	217
	QSMODE	1.4803E+01	1.4953E+01	1.4953E+01	1.4947E+01	2.7280E-02	100	11
	DQSMODE	1.4950E+01	1.4953E+01	1.4953E+01	1.4952E+01	7.1153E-04	100	11

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M28-M34).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M28	A*	1.1135E+01	1.1135E+01	1.1135E+01	1.1135E+01	1.8067E-15	100	69
	Dijkstra	1.1027E+01	1.1027E+01	1.1027E+01	1.1027E+01	5.4202E-15	100	69
	RRT	1.1662E+01	2.8967E+01	1.3674E+01	1.4917E+01	3.9537E+00	100	30
	RRT*	1.1499E+01	2.8223E+01	1.3476E+01	1.4836E+01	4.2936E+00	100	30
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.5907E+01	1.5907E+01	1.5907E+01	1.5907E+01	5.4202E-15	100	559
	QSMODE	1.0821E+01	4.5309E+01	1.8062E+01	1.8277E+01	5.5606E+00	100	7
	DQSMODE	1.8061E+01	1.8178E+01	1.8062E+01	1.8088E+01	4.6381E-02	100	7
M29	A*	1.1027E+01	1.1027E+01	1.1027E+01	1.1027E+01	5.4202E-15	100	70
	Dijkstra	1.0928E+01	1.0928E+01	1.0928E+01	1.0928E+01	1.8067E-15	100	70
	RRT	1.1517E+01	2.3146E+01	1.2403E+01	1.2986E+01	2.1246E+00	100	30
	RRT*	1.1258E+01	1.5059E+01	1.2573E+01	1.2750E+01	8.1049E-01	100	24
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.4504E+01	1.4504E+01	1.4504E+01	1.4504E+01	7.2269E-15	100	564
	QSMODE	1.0414E+01	1.0478E+01	1.0478E+01	1.0475E+01	1.1847E-02	100	8
	DQSMODE	1.0453E+01	1.0478E+01	1.0478E+01	1.0476E+01	4.7632E-03	100	8
M30	A*	8.9604E+00	8.9604E+00	8.9604E+00	8.9604E+00	0.0000E+00	100	55
	Dijkstra	8.8438E+00	8.8438E+00	8.8438E+00	8.8438E+00	7.2269E-15	100	55
	RRT	9.0860E+00	3.9012E+01	1.3522E+01	2.0747E+01	1.1417E+01	100	35
	RRT*	8.4839E+00	3.9324E+01	1.0565E+01	1.7109E+01	1.1043E+01	100	31
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	1.7939E+01	4.6860E+01	1.8353E+01	2.4973E+01	1.1220E+01	100	9
	DQSMODE	1.7928E+01	4.4677E+01	1.8214E+01	2.1634E+01	8.8806E+00	100	9
M31	A*	1.9525E+01	1.9525E+01	1.9525E+01	1.9525E+01	0.0000E+00	100	122
	Dijkstra	1.9740E+01	1.9740E+01	1.9740E+01	1.9740E+01	3.6134E-15	100	122
	RRT	2.0851E+01	2.8308E+01	2.2482E+01	2.2951E+01	1.7046E+00	100	32
	RRT*	2.0478E+01	2.8733E+01	2.2071E+01	2.2570E+01	1.7654E+00	100	33
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.7594E+01	2.7594E+01	2.7594E+01	2.7594E+01	0.0000E+00	100	470
	QSMODE	2.0081E+01	2.0087E+01	2.0081E+01	2.0082E+01	1.0549E-03	100	8
	DQSMODE	2.0081E+01	2.0082E+01	2.0081E+01	2.0081E+01	3.2539E-04	100	8
M32	A*	1.4337E+01	1.4337E+01	1.4337E+01	1.4337E+01	9.0336E-15	100	89
	Dijkstra	1.4317E+01	1.4317E+01	1.4317E+01	1.4317E+01	7.2269E-15	100	89
	RRT	1.4446E+01	2.4243E+01	1.5721E+01	1.6655E+01	2.2481E+00	100	27
	RRT*	1.4475E+01	2.2740E+01	1.6031E+01	1.6390E+01	1.6791E+00	100	26
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.5207E+01	1.5207E+01	1.5207E+01	1.5207E+01	7.2269E-15	100	212
	QSMODE	1.5629E+01	1.8903E+01	1.6255E+01	1.6976E+01	1.1438E+00	100	10
	DQSMODE	1.6245E+01	1.8518E+01	1.6251E+01	1.6478E+01	6.9130E-01	100	10
M33	A*	3.6847E+02	3.6847E+02	3.6847E+02	3.6847E+02	2.3126E-13	100	89
	Dijkstra	1.4710E+01	1.4710E+01	1.4710E+01	1.4710E+01	9.0336E-15	100	89
	RRT	1.6566E+01	2.5612E+01	1.8429E+01	1.8846E+01	1.8301E+00	100	37
	RRT*	1.6899E+01	6.0873E+01	1.9224E+01	2.0660E+01	7.8353E+00	100	36
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.0439E+01	2.0439E+01	2.0439E+01	2.0439E+01	3.6134E-15	100	587
	QSMODE	1.5710E+01	1.5783E+01	1.5734E+01	1.5736E+01	1.7684E-02	100	14
	DQSMODE	1.5708E+01	1.5812E+01	1.5726E+01	1.5729E+01	1.7262E-02	100	14
M34	A*	1.8123E+01	1.8123E+01	1.8123E+01	1.8123E+01	7.2269E-15	100	108
	Dijkstra	1.8161E+01	1.8161E+01	1.8161E+01	1.8161E+01	1.0840E-14	100	108
	RRT	1.9037E+01	3.0130E+01	2.0159E+01	2.1320E+01	2.9626E+00	100	35
	RRT*	1.8696E+01	2.9697E+01	1.9706E+01	2.0470E+01	2.3951E+00	100	36
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.9433E+01	1.9433E+01	1.9433E+01	1.9433E+01	0.0000E+00	100	256
	QSMODE	1.6959E+01	1.9367E+01	1.6969E+01	1.7755E+01	1.1191E+00	100	12
	DQSMODE	1.6958E+01	1.9367E+01	1.7036E+01	1.7840E+01	1.1279E+00	100	12

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M35-M41).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M35	A*	1.7019E+01	1.7019E+01	1.7019E+01	1.7019E+01	0.0000E+00	100	101
	Dijkstra	1.6273E+01	1.6273E+01	1.6273E+01	1.6273E+01	7.2269E-15	100	95
	RRT	1.5179E+01	2.5699E+01	1.6349E+01	1.7592E+01	2.6159E+00	100	30
	RRT*	1.4965E+01	2.4656E+01	1.6029E+01	1.6718E+01	2.1162E+00	100	27
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.4863E+01	1.4863E+01	1.4863E+01	1.4863E+01	5.4202E-15	100	253
	QSMODE	1.4092E+01	3.1336E+01	2.8663E+01	2.3930E+01	6.9606E+00	100	16
	DQSMODE	1.4093E+01	2.9459E+01	2.8876E+01	2.5767E+01	6.0526E+00	100	16
M36	A*	7.2621E+00	7.2621E+00	7.2621E+00	7.2621E+00	9.0336E-16	100	41
	Dijkstra	7.1166E+00	7.1166E+00	7.1166E+00	7.1166E+00	2.7101E-15	100	41
	RRT	6.8743E+00	8.1609E+00	7.3358E+00	7.4067E+00	2.9164E-01	100	16
	RRT*	7.0950E+00	8.6519E+00	7.4638E+00	7.5365E+00	3.4896E-01	100	20
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	7.2694E+00	7.2694E+00	7.2694E+00	7.2694E+00	1.8067E-15	100	152
	QSMODE	1.4906E+01	2.0863E+01	2.0820E+01	1.9652E+01	2.3945E+00	100	12
	DQSMODE	1.4906E+01	2.0872E+01	2.0809E+01	1.8489E+01	2.9251E+00	100	12
M37	A*	1.2867E+01	1.2867E+01	1.2867E+01	1.2867E+01	5.4202E-15	100	74
	Dijkstra	1.2576E+01	1.2576E+01	1.2576E+01	1.2576E+01	7.2269E-15	100	73
	RRT	1.2450E+01	2.2684E+01	1.5939E+01	1.6313E+01	2.4708E+00	100	30
	RRT*	1.3458E+01	2.5040E+01	1.5743E+01	1.6301E+01	2.5189E+00	100	33
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	2.2995E+01	6.1632E+01	4.5169E+01	4.4323E+01	1.4792E+01	100	16
	DQSMODE	2.3065E+01	5.9787E+01	4.4910E+01	4.5429E+01	1.4149E+01	100	16
M38	A*	1.4340E+01	1.4340E+01	1.4340E+01	1.4340E+01	1.0840E-14	100	79
	Dijkstra	1.4241E+01	1.4241E+01	1.4241E+01	1.4241E+01	7.2269E-15	100	78
	RRT	1.4964E+01	2.3757E+01	1.6575E+01	1.7612E+01	2.2285E+00	100	35
	RRT*	1.5428E+01	5.7543E+01	1.6587E+01	1.9310E+01	8.0216E+00	100	33
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	QSMODE	1.3604E+01	1.3608E+01	1.3604E+01	1.3605E+01	7.8769E-04	100	4
	DQSMODE	1.3604E+01	1.3606E+01	1.3605E+01	1.3605E+01	4.9417E-04	100	4
M39	A*	1.6288E+01	1.6288E+01	1.6288E+01	1.6288E+01	1.0840E-14	100	95
	Dijkstra	1.6427E+01	1.6427E+01	1.6427E+01	1.6427E+01	0.0000E+00	100	95
	RRT	1.6241E+01	2.0519E+01	1.7196E+01	1.7332E+01	8.3596E-01	100	34
	RRT*	1.6096E+01	1.8205E+01	1.6975E+01	1.6994E+01	5.1670E-01	100	31
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.6301E+01	1.6301E+01	1.6301E+01	1.6301E+01	3.6134E-15	100	227
	QSMODE	1.5211E+01	1.5264E+01	1.5263E+01	1.5260E+01	1.2511E-02	100	8
	DQSMODE	1.5210E+01	1.5264E+01	1.5239E+01	1.5238E+01	2.5802E-02	100	8
M40	A*	1.2779E+01	1.2779E+01	1.2779E+01	1.2779E+01	1.8067E-15	100	72
	Dijkstra	1.2456E+01	1.2456E+01	1.2456E+01	1.2456E+01	3.6134E-15	100	69
	RRT	1.2235E+01	1.5484E+01	1.2704E+01	1.2923E+01	6.7557E-01	100	28
	RRT*	1.2345E+01	1.5270E+01	1.2837E+01	1.2884E+01	5.4203E-01	100	28
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.2451E+01	1.2451E+01	1.2451E+01	1.2451E+01	1.8067E-15	100	189
	QSMODE	1.1701E+01	1.1701E+01	1.1701E+01	1.1701E+01	6.3079E-05	100	8
	DQSMODE	1.1701E+01	1.1701E+01	1.1701E+01	1.1701E+01	3.8831E-05	100	8
M41	A*	1.4759E+01	1.4759E+01	1.4759E+01	1.4759E+01	0.0000E+00	100	88
	Dijkstra	1.4447E+01	1.4447E+01	1.4447E+01	1.4447E+01	3.6134E-15	100	82
	RRT	1.3825E+01	1.6573E+01	1.5044E+01	1.5109E+01	5.1719E-01	100	28
	RRT*	1.4123E+01	1.6847E+01	1.5048E+01	1.5192E+01	5.9781E-01	100	28
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.4140E+01	1.4140E+01	1.4140E+01	1.4140E+01	0.0000E+00	100	206
	QSMODE	1.3584E+01	1.4204E+01	1.4193E+01	1.4005E+01	2.7668E-01	100	12
	DQSMODE	1.3584E+01	1.4204E+01	1.3596E+01	1.3774E+01	2.8310E-01	100	12

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M42-M48).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M42	A*	1.4267E+01	1.4267E+01	1.4267E+01	1.4267E+01	9.0336E-15	100	72
	Dijkstra	1.3568E+01	1.3568E+01	1.3568E+01	1.3568E+01	0.0000E+00	100	72
	RRT	1.3535E+01	1.7445E+01	1.5759E+01	1.5486E+01	1.0194E+00	100	30
	RRT*	1.3173E+01	1.9990E+01	1.5888E+01	1.5860E+01	1.3752E+00	100	28
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.3114E+01	1.3114E+01	1.3114E+01	1.3114E+01	3.6134E-15	100	191
	QSMODE	1.3040E+01	1.3041E+01	1.3040E+01	1.3040E+01	2.6277E-04	100	10
	DQSMODE	1.3040E+01	1.3040E+01	1.3040E+01	1.3040E+01	1.1989E-04	100	10
M43	A*	1.5798E+01	1.5798E+01	1.5798E+01	1.5798E+01	1.8067E-15	100	89
	Dijkstra	1.5899E+01	1.5899E+01	1.5899E+01	1.5899E+01	7.2269E-15	100	89
	RRT	1.5297E+01	1.7302E+01	1.6106E+01	1.6082E+01	4.1676E-01	100	32
	RRT*	1.5563E+01	1.7096E+01	1.6027E+01	1.6027E+01	3.5942E-01	100	29
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.5792E+01	1.5792E+01	1.5792E+01	1.5792E+01	1.8067E-15	100	222
	QSMODE	1.4723E+01	1.4750E+01	1.4750E+01	1.4747E+01	7.9883E-03	100	10
	DQSMODE	1.4723E+01	1.4750E+01	1.4749E+01	1.4747E+01	8.1296E-03	100	10
M44	A*	1.4243E+01	1.4243E+01	1.4243E+01	1.4243E+01	9.0336E-15	100	85
	Dijkstra	1.3891E+01	1.3891E+01	1.3891E+01	1.3891E+01	9.0336E-15	100	85
	RRT	1.5001E+01	2.8235E+01	1.8233E+01	2.0061E+01	4.2418E+00	100	31
	RRT*	1.4203E+01	3.4135E+01	1.8185E+01	1.9787E+01	5.3474E+00	100	23
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	2.5843E+01	2.5843E+01	2.5843E+01	2.5843E+01	1.0840E-14	100	863
	QSMODE	1.2872E+01	2.2953E+01	1.2874E+01	1.4698E+01	3.7939E+00	100	14
	DQSMODE	1.2872E+01	2.2952E+01	1.2873E+01	1.3368E+01	2.0025E+00	100	14
M45	A*	2.0257E+01	2.0257E+01	2.0257E+01	2.0257E+01	0.0000E+00	100	107
	Dijkstra	1.9937E+01	1.9937E+01	1.9937E+01	1.9937E+01	1.0840E-14	100	107
	RRT	1.9829E+01	2.3763E+01	2.1091E+01	2.1321E+01	1.0145E+00	100	34
	RRT*	1.9720E+01	2.4865E+01	2.0917E+01	2.1231E+01	1.3005E+00	100	30
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.9309E+01	1.9309E+01	1.9309E+01	1.9309E+01	0.0000E+00	100	254
	QSMODE	1.8892E+01	1.9306E+01	1.8902E+01	1.9024E+01	1.5159E-01	100	16
	DQSMODE	1.8892E+01	1.9330E+01	1.8894E+01	1.8992E+01	1.4391E-01	100	16
M46	A*	1.0208E+01	1.0208E+01	1.0208E+01	1.0208E+01	0.0000E+00	100	61
	Dijkstra	1.0117E+01	1.0117E+01	1.0117E+01	1.0117E+01	1.8067E-15	100	61
	RRT	1.0146E+01	3.1045E+01	1.1159E+01	1.2855E+01	4.4519E+00	100	24
	RRT*	1.0075E+01	1.6952E+01	1.1088E+01	1.1607E+01	1.8456E+00	100	21
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.0313E+01	1.0313E+01	1.0313E+01	1.0313E+01	1.8067E-15	100	174
	QSMODE	9.5564E+00	9.5909E+00	9.5601E+00	9.5614E+00	6.6729E-03	100	16
	DQSMODE	9.5565E+00	9.5680E+00	9.5605E+00	9.5603E+00	2.9634E-03	100	16
M47	A*	1.0720E+01	1.0720E+01	1.0720E+01	1.0720E+01	5.4202E-15	100	63
	Dijkstra	1.0515E+01	1.0515E+01	1.0515E+01	1.0515E+01	5.4202E-15	100	62
	RRT	1.1810E+01	4.3961E+01	1.3350E+01	1.5861E+01	6.4863E+00	100	19
	RRT*	1.1333E+01	3.4502E+01	1.4145E+01	1.6931E+01	6.3672E+00	100	18
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.1890E+01	1.1890E+01	1.1890E+01	1.1890E+01	9.0336E-15	100	203
	QSMODE	1.0079E+01	1.0098E+01	1.0084E+01	1.0084E+01	4.4331E-03	100	16
	DQSMODE	1.0079E+01	1.0089E+01	1.0082E+01	1.0083E+01	3.4704E-03	100	16
M48	A*	1.4504E+01	1.4504E+01	1.4504E+01	1.4504E+01	7.2269E-15	100	79
	Dijkstra	1.4482E+01	1.4482E+01	1.4482E+01	1.4482E+01	7.2269E-15	100	79
	RRT	1.4050E+01	3.0456E+01	1.5322E+01	1.6047E+01	2.9021E+00	100	23
	RRT*	1.4235E+01	2.2621E+01	1.5483E+01	1.5842E+01	1.6297E+00	100	25
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.4605E+01	1.4605E+01	1.4605E+01	1.4605E+01	1.0840E-14	100	206
	QSMODE	1.3484E+01	1.3486E+01	1.3485E+01	1.3485E+01	3.3845E-04	100	19
	DQSMODE	1.3484E+01	1.3485E+01	1.3485E+01	1.3485E+01	3.0690E-04	100	19

Table S6 (Cont.):Best, worst, median, mean, and SD, success rate and No. of Waypoints Results of all the 8 algorithms across the 30 runs for the models (M49-M50).

M No.	Alg. Name	Path Cost					SR (%)	No. Pts
		Best	Worst	Median	Mean	SD		
M49	A*	1.0059E+01	1.0059E+01	1.0059E+01	1.0059E+01	5.4202E-15	100	60
	Dijkstra	9.8669E+00	9.8669E+00	9.8669E+00	9.8669E+00	9.0336E-15	100	59
	RRT	1.1054E+01	2.1407E+01	1.2894E+01	1.3265E+01	1.9322E+00	100	21
	RRT*	1.1241E+01	2.5344E+01	1.3333E+01	1.4486E+01	3.1601E+00	100	21
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.1405E+01	1.1405E+01	1.1405E+01	1.1405E+01	0.0000E+00	100	189
	QSMODE	9.9591E+00	9.9755E+00	9.9623E+00	9.9637E+00	3.9997E-03	100	19
	DQSMODE	9.9601E+00	9.9714E+00	9.9620E+00	9.9629E+00	2.5136E-03	100	19
M50	A*	1.2494E+01	1.2494E+01	1.2494E+01	1.2494E+01	9.0336E-15	100	69
	Dijkstra	1.2278E+01	1.2278E+01	1.2278E+01	1.2278E+01	5.4202E-15	100	69
	RRT	1.2812E+01	3.3375E+01	1.5790E+01	1.7205E+01	4.4870E+00	100	22
	RRT*	1.2535E+01	4.1799E+01	1.5991E+01	1.8257E+01	6.6178E+00	100	17
	APF	6.5535E+04	6.5535E+04	6.5535E+04	6.5535E+04	0.0000E+00	0	0
	DWA	1.1839E+01	1.1839E+01	1.1839E+01	1.1839E+01	3.6134E-15	100	195
	QSMODE	1.1546E+01	1.2550E+01	1.2097E+01	1.2049E+01	1.9284E-01	100	22
	DQSMODE	1.1514E+01	1.2550E+01	1.2097E+01	1.2136E+01	3.0536E-01	100	22

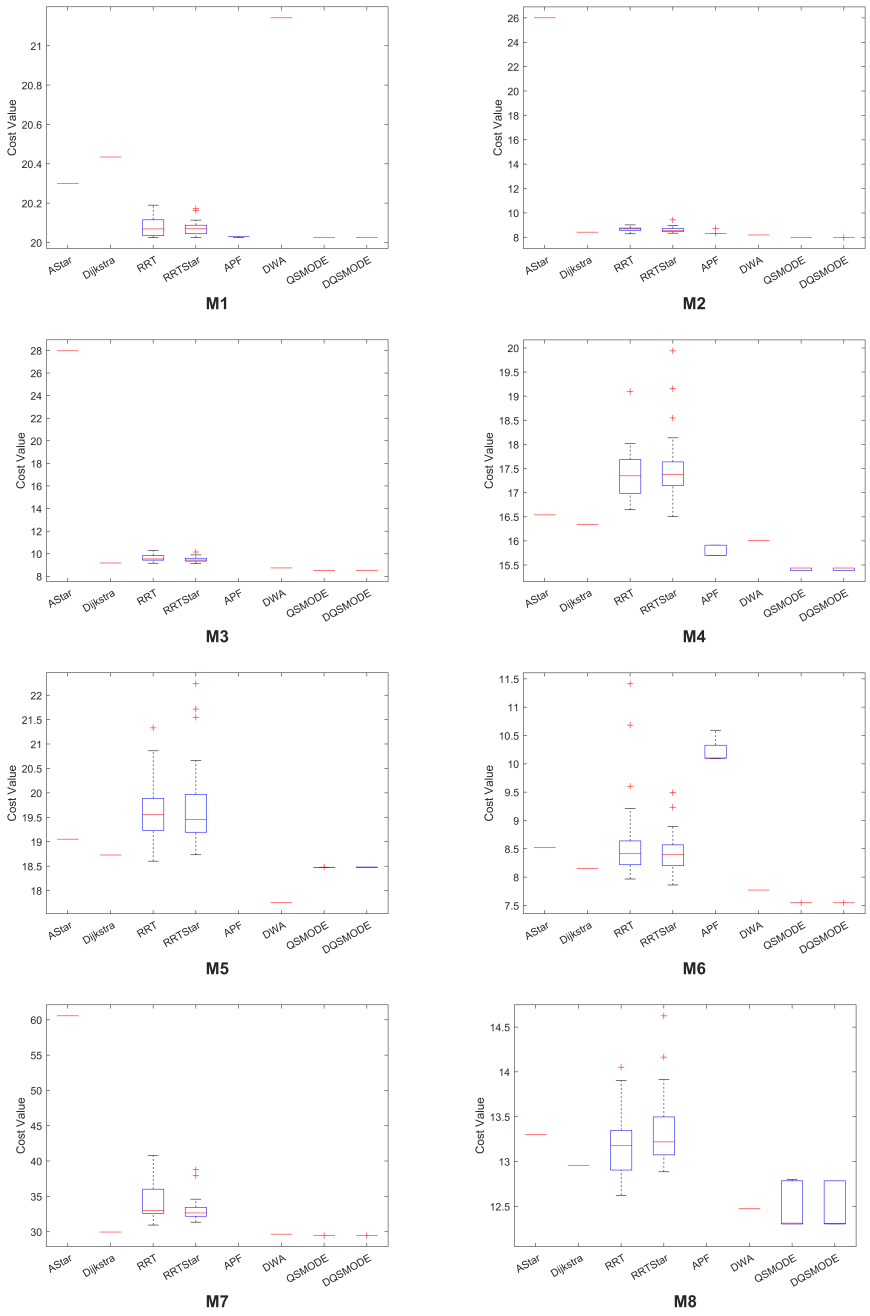


Figure S11: Box plots for all the 8 path-planning algorithms in 30 runs for all models.

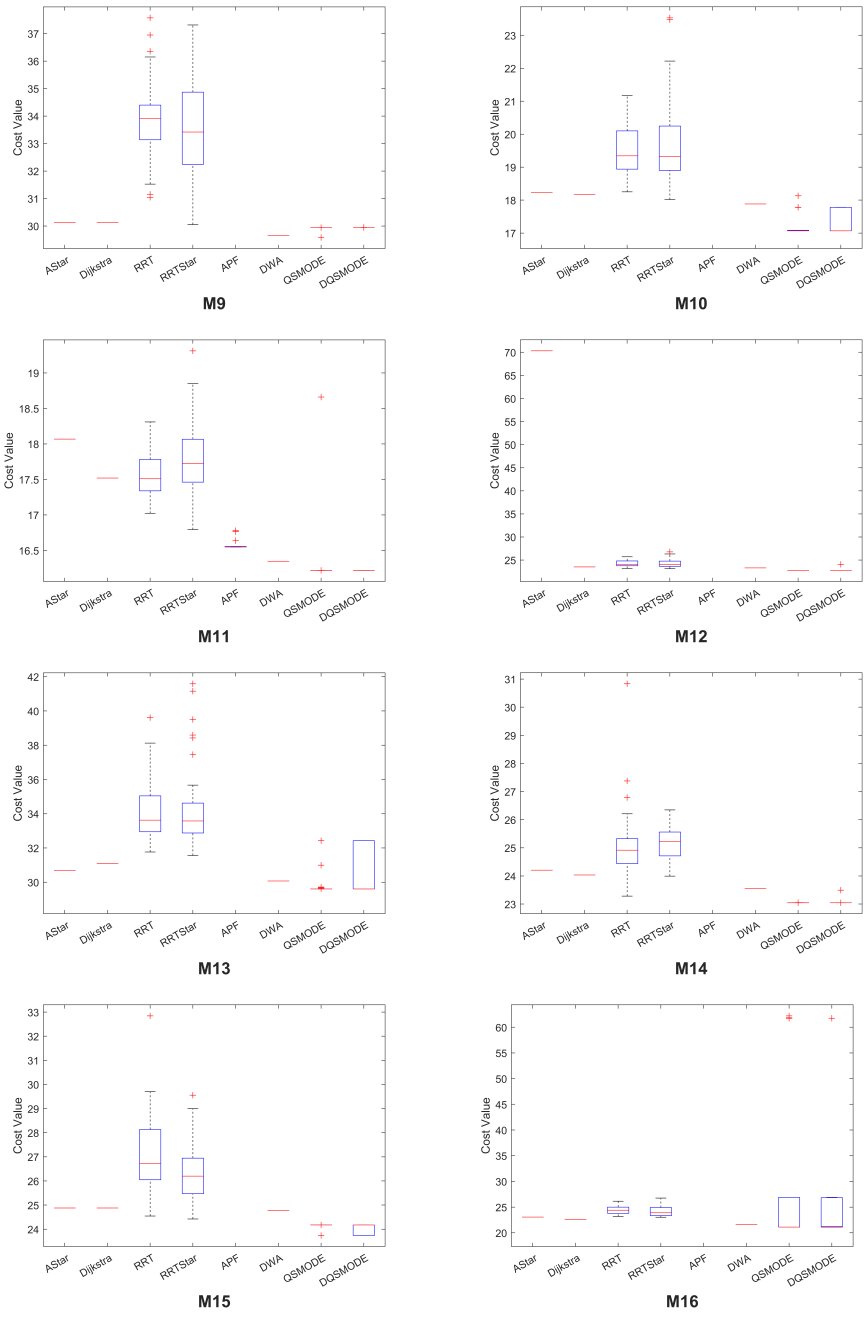


Figure S11 (Cont.): Box plots for all the 8 path-planning algorithms in 30 runs for all models.

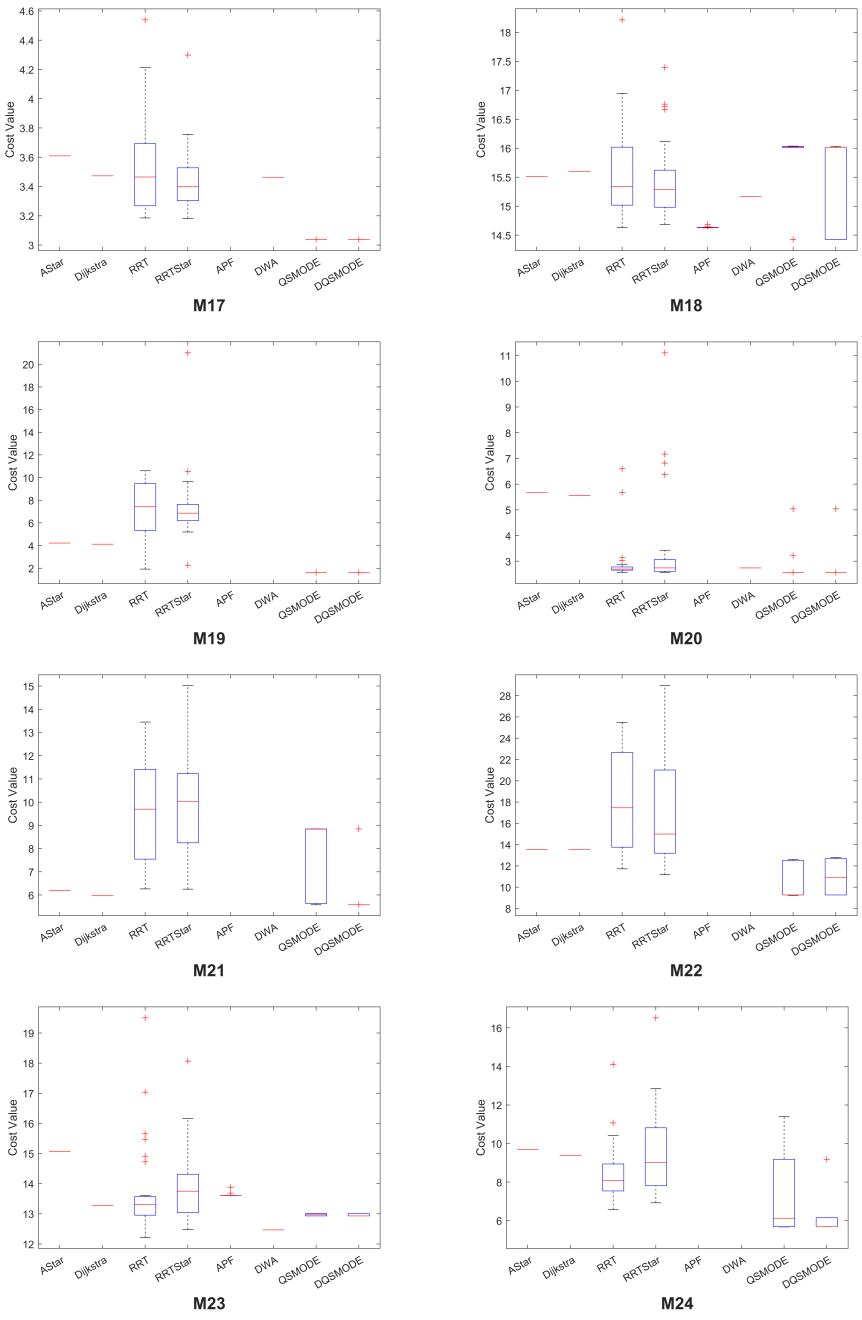


Figure S11 (Cont.): Box plots for all the 8 path-planning algorithms in 30 runs for all models.

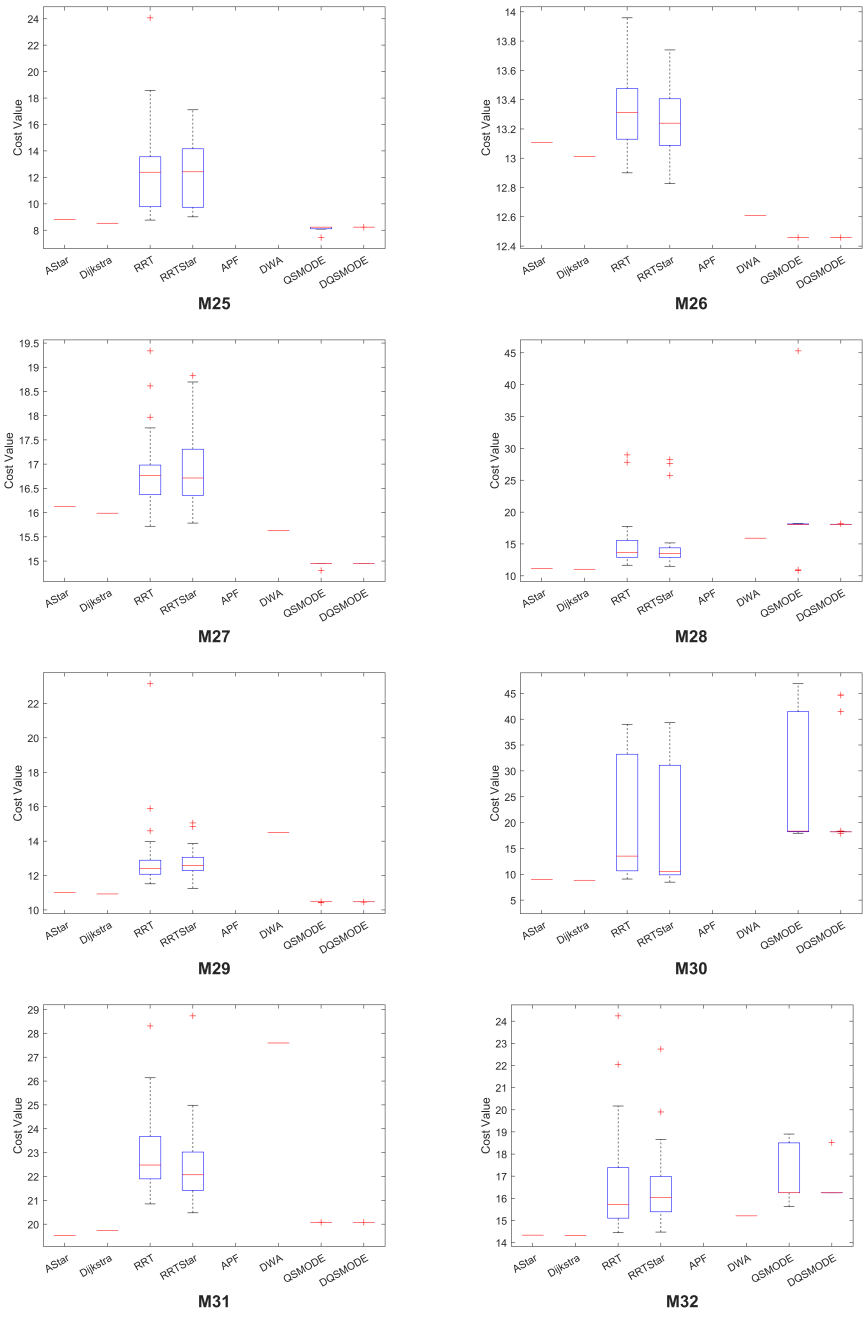


Figure S11 (Cont.): Box plots for all the 8 path-planning algorithms in 30 runs for all models.

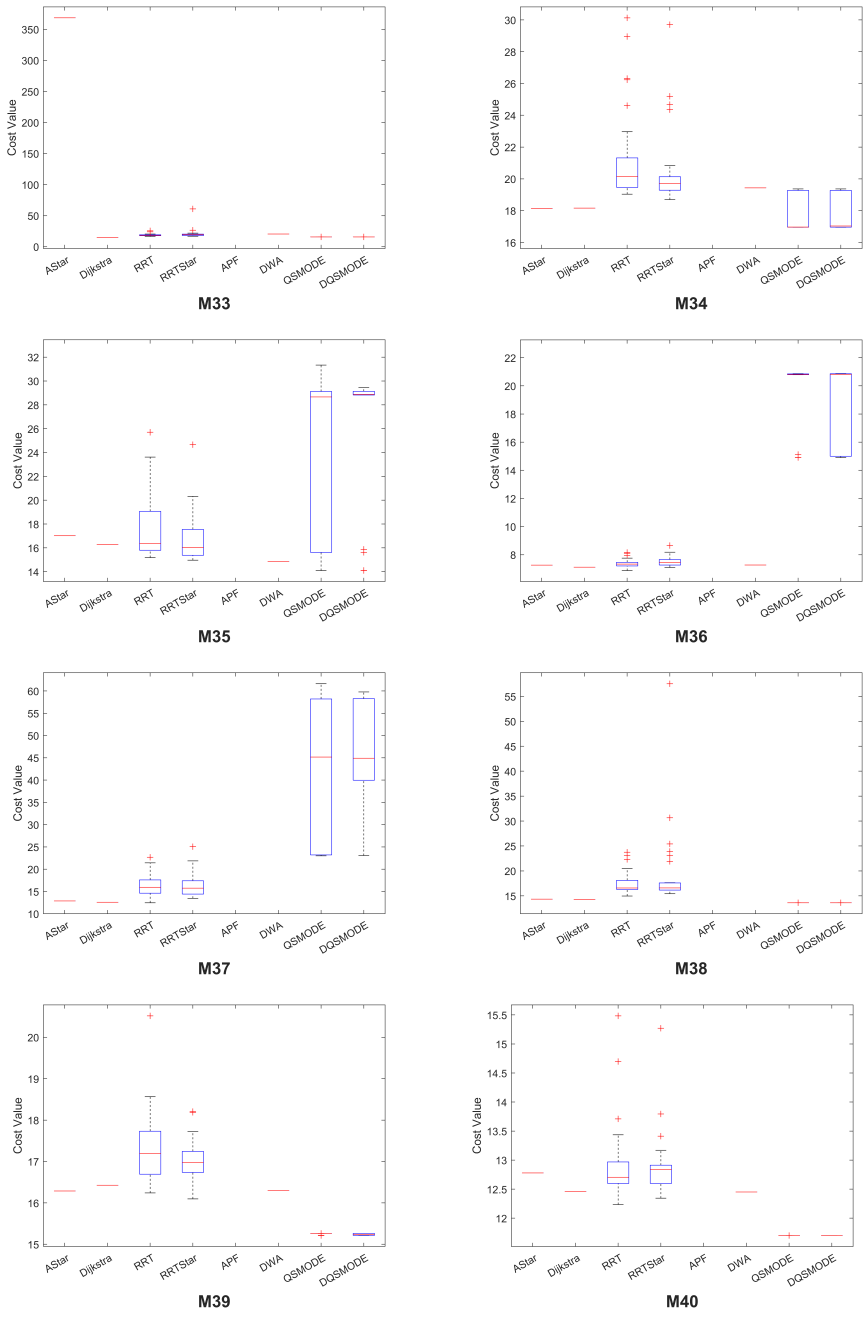


Figure S11 (Cont.): Box plots for all the 8 path-planning algorithms in 30 runs for all models.

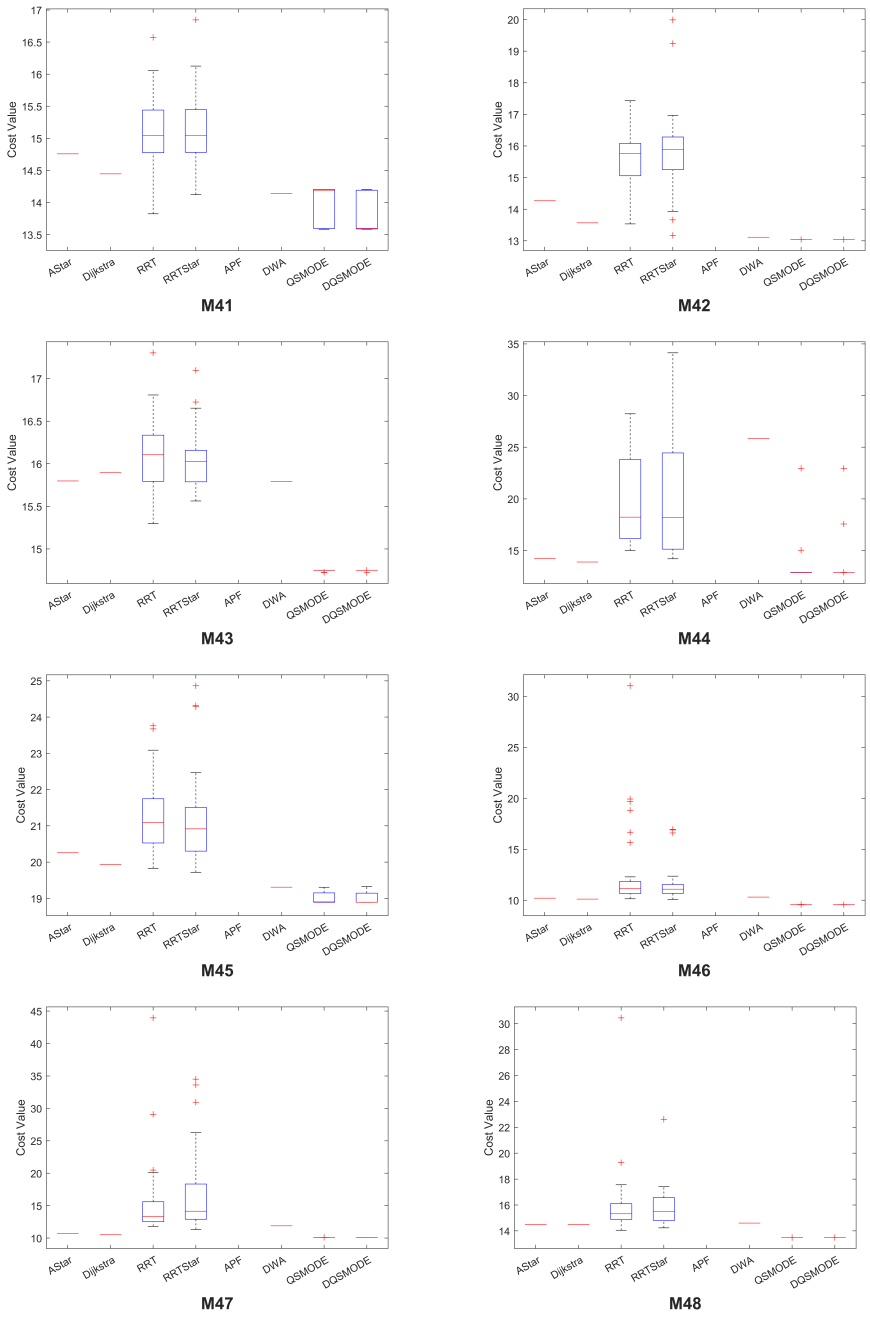


Figure S11 (Cont.): Box plots for all the 8 path-planning algorithms in 30 runs for all models.

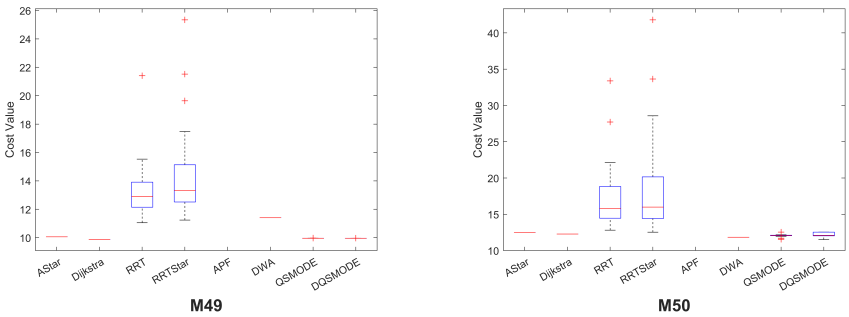


Figure S11 (Cont.): Box plots for all the 8 path-planning algorithms in 30 runs for all models.

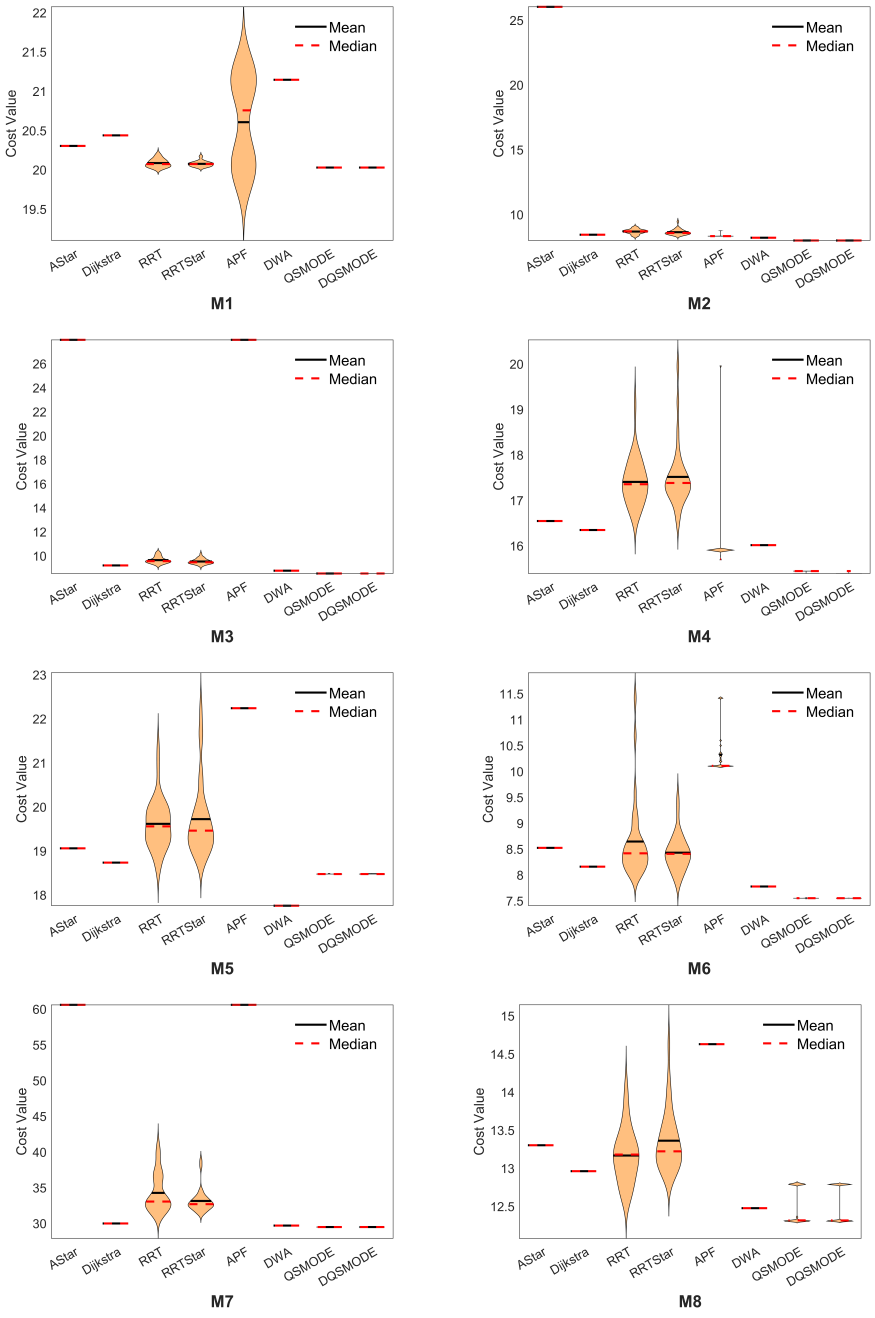


Figure S12: Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

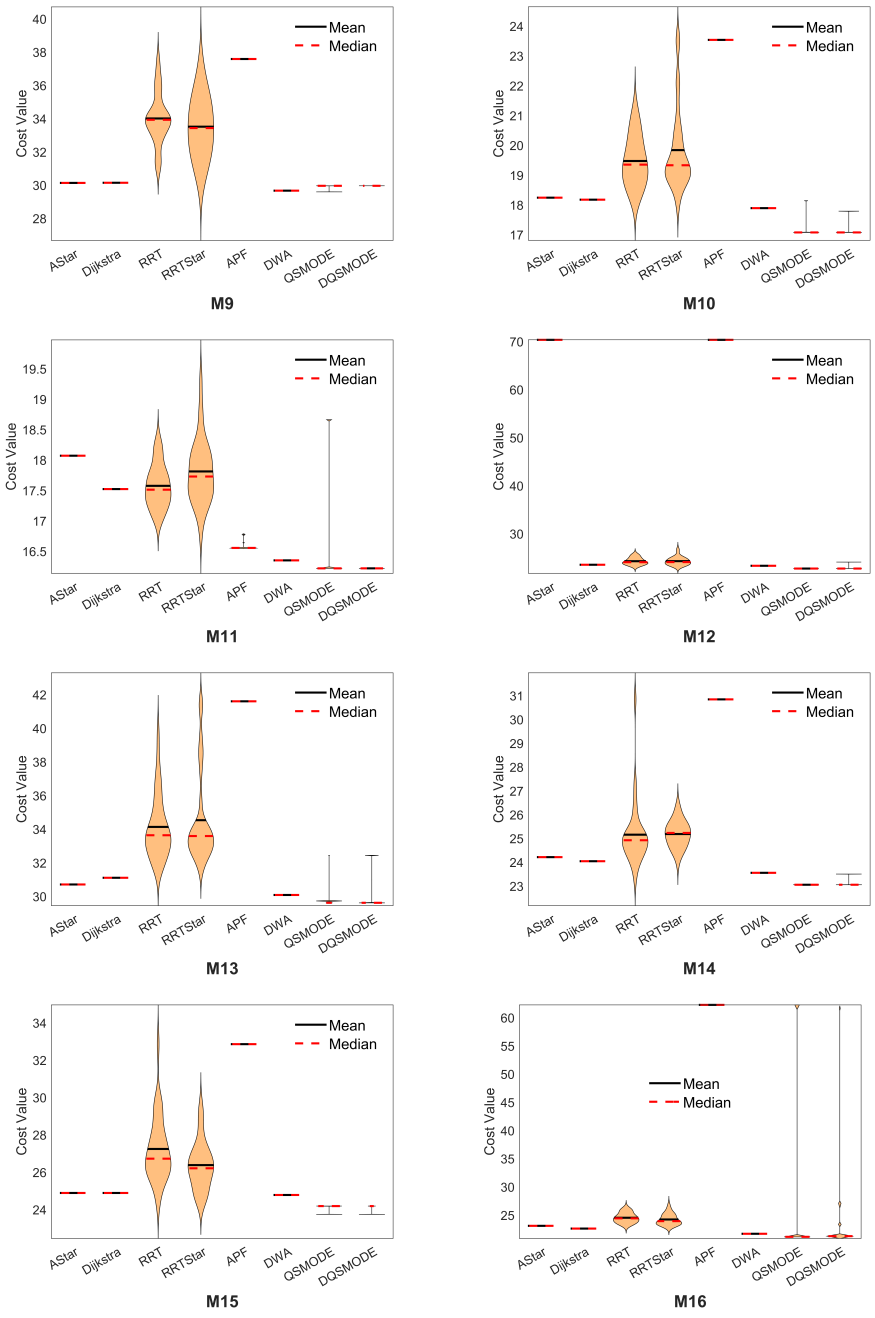


Figure S12 (Cont.): Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

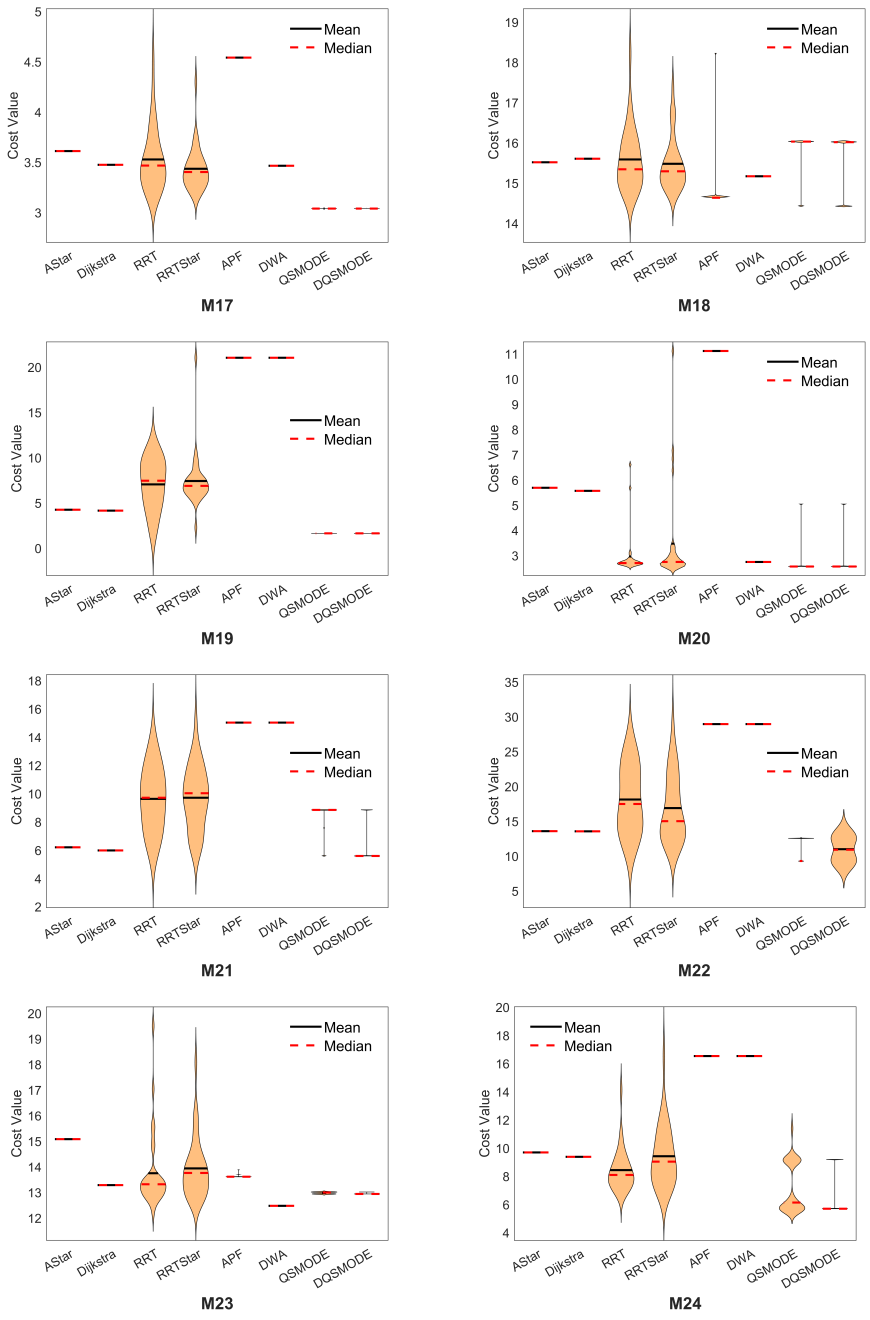


Figure S12 (Cont.): Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

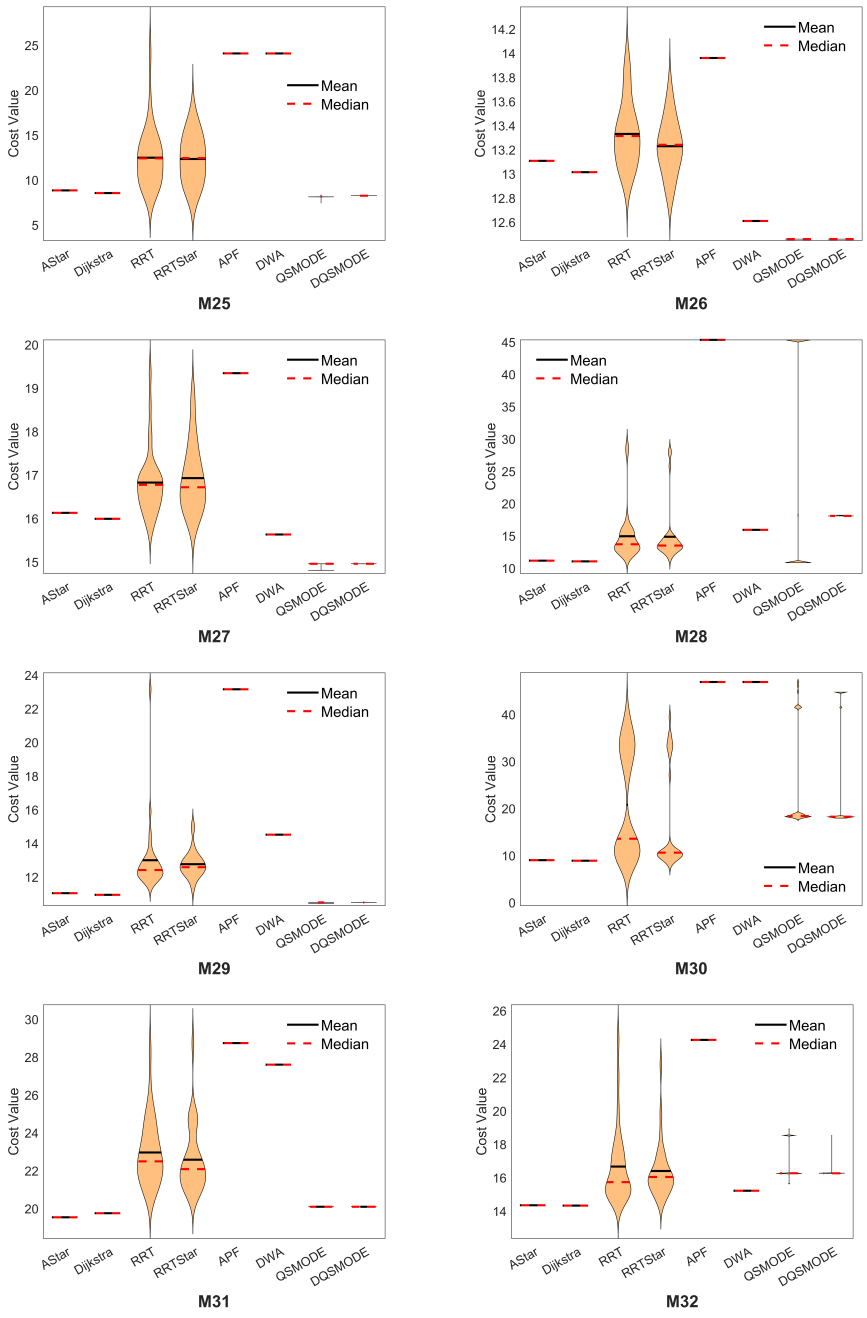


Figure S12 (Cont.): Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

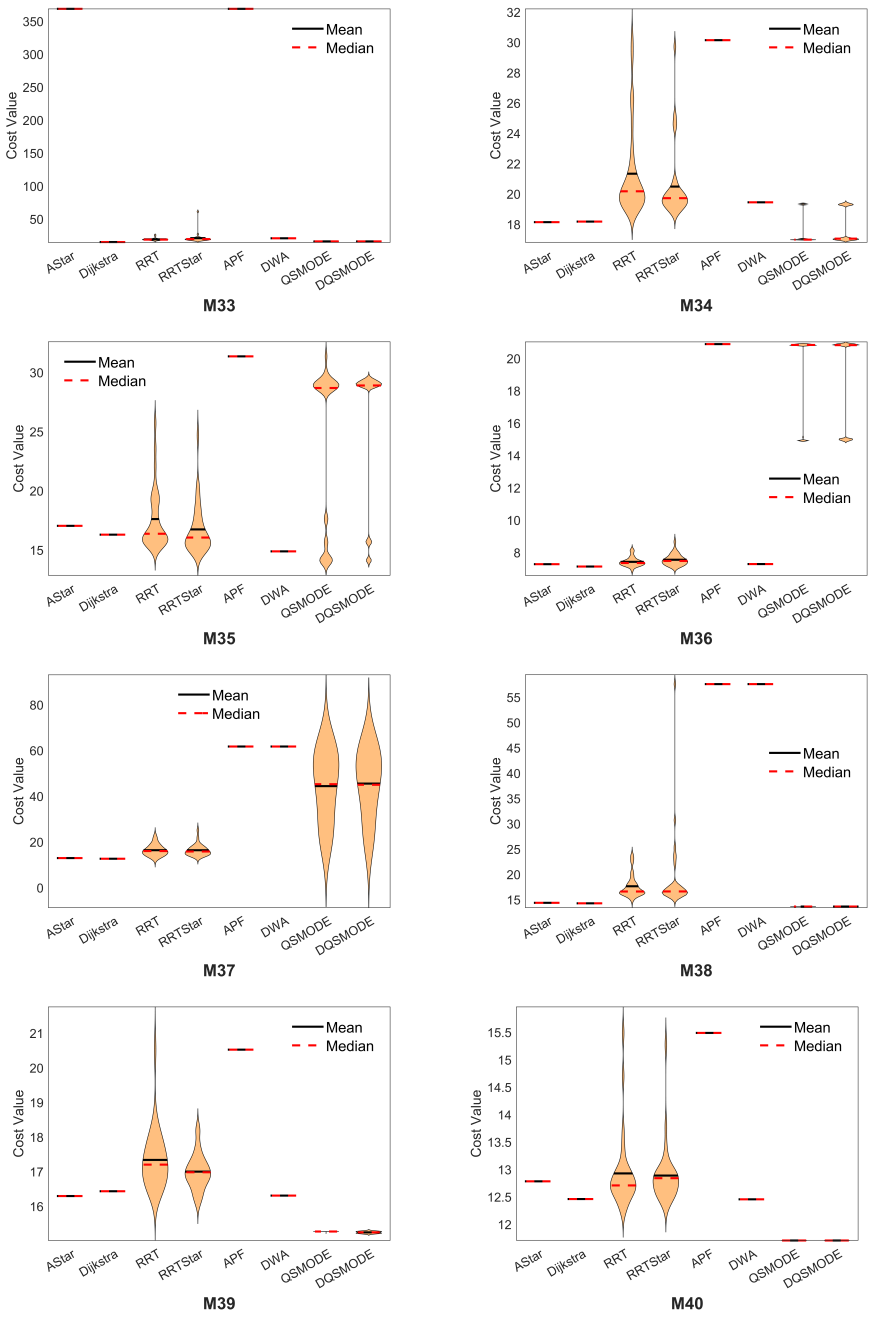


Figure S12 (Cont.): Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

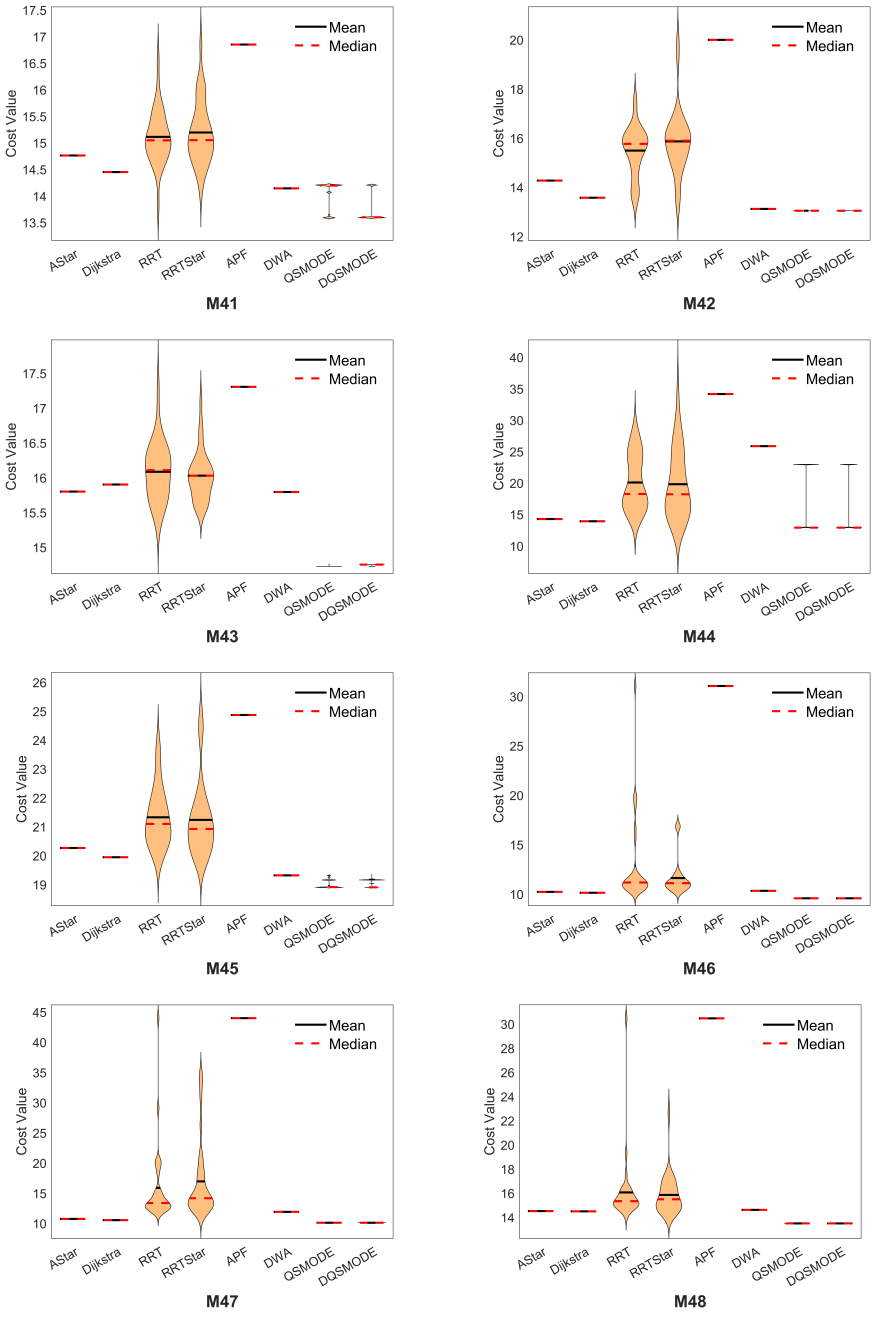


Figure S12 (Cont.): Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

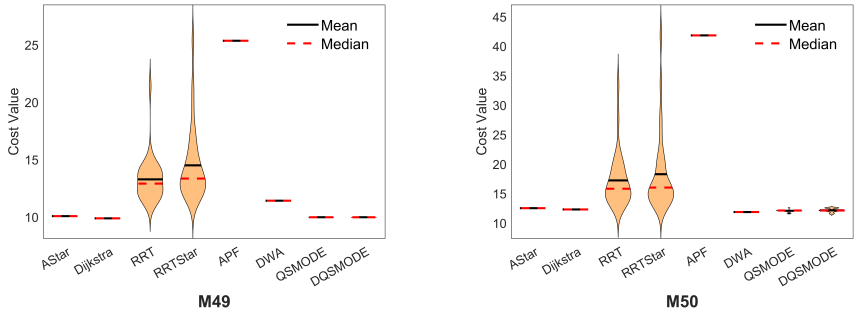


Figure S12 (Cont.): Violin plots for all the 8 path-planning algorithms in 30 runs for all models.

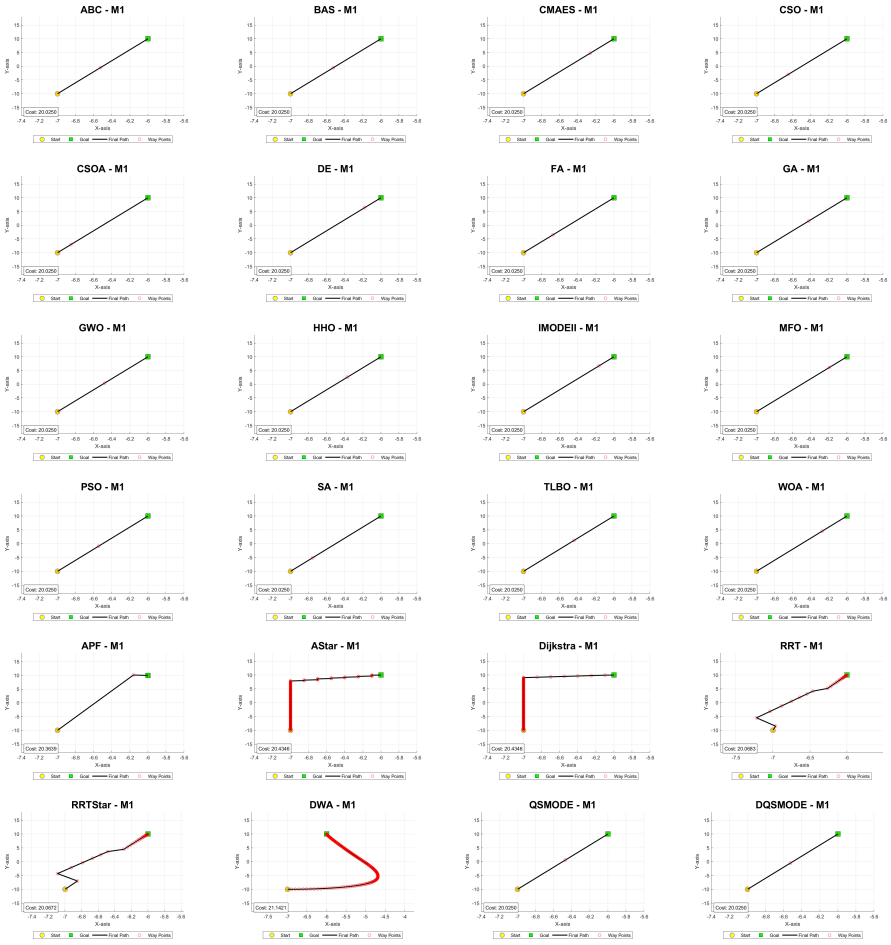
Table S7: Statistical Analysis of group comparison for all 50 models for all the 8 path-planning algorithms: A*, Dijkstra, RRT, RRT*, DWA, APF, QSMODE, and DQSMODE. In the Friedman test, the best algorithm is the one with the minimum mean rank. The significance level α is between 0.05 and 0.1. The results are significant if p-value $< \alpha$. In SNE-SR ranking test, SNE is the sum of normalized error, SR is the sum rank, the score is out of 100, and the best algorithm is the one with the highest score.

Alg.	Friedman Test			SNE-SR Ranking Test					
	sum rank	mean rank	rank	SNE	Score1	SR	Score2	Score	Rank
A*	229	4.58	5	7.8849	39.5143	229	25.2183	64.7327	6
Dijkstra	174	3.48	3	6.5669	47.4451	174	33.1897	80.6348	3
RRT	287	5.74	7	6.3797	48.8374	287	20.1220	68.9593	5
RRT*	277	5.54	6	6.3706	48.9072	277	20.8484	69.7556	4
APF	385	7.7	8	48.9654	6.3630	385	15.0000	21.3630	8
DWA	198	3.96	4	14.3365	21.7324	198	29.1667	50.8991	7
QSMODE	134.5	2.69	2	6.2313	50.0000	134.5	42.9368	92.9368	2
DQSMODE	115.5	2.31	1	6.2406	49.9258	115.5	50.0000	99.9258	1
	p-val	1.06203E-36							

Table S8: Detailed Wilcoxon test for all 50 models for all the 8 path-planning algorithms across all the five model categories: open-field, single-obstacle, multi-obstacles, narrow-passages, and maze-like. DQSMODE is the reference algorithm in all paired comparisons. '+' means the number of models in which the DQSMODE is better, and '=' means draw. R+ > R- means the DQSMODE is better. The significance level α is between 0.05 and 0.1. The results are significant if p-value $< \alpha$.

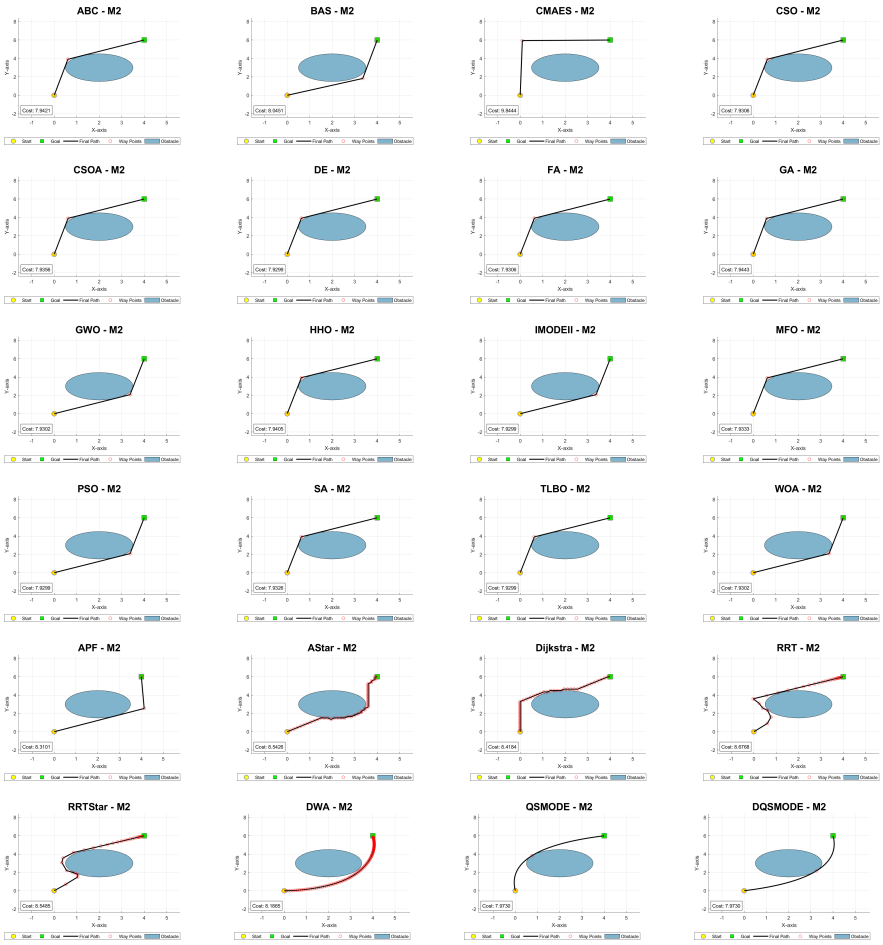
DQSMODE vs.	Open-Field	Single-Obst.	Multi-Obst.	Narrow-Passage	Maze-like	Total	R+	R-	p-val	H
A*	+1/=0/-0	+2/=0/-0	+12/=0/-1	+13/=0/-8	+13/=0/-0	+41/=0/-9	978	297	1.0128E-03	TRUE
Dijkstra	+1/=0/-0	+2/=0/-0	+12/=0/-1	+12/=0/-9	+12/=0/-1	+39/=0/-11	903	372	1.0379E-02	TRUE
RRT	+1/=0/-0	+2/=0/-0	+13/=0/-0	+15/=0/-6	+13/=0/-0	+44/=0/-6	1084	191	1.6312E-05	TRUE
RRT*	+1/=0/-0	+2/=0/-0	+12/=0/-1	+14/=0/-7	+13/=0/-0	+42/=0/-8	1046	229	8.0346E-05	TRUE
APF	+1/=0/-0	+2/=0/-0	+13/=0/-0	+21/=0/-0	+13/=0/-0	+50/=0/-0	1275	0	7.5569E-10	TRUE
DWA	+1/=0/-0	+2/=0/-0	+8/=0/-5	+14/=0/-7	+12/=0/-1	+37/=0/-13	994	281	5.7873E-04	TRUE
QSMODE	+0/=1/-0	+0/=0/-2	+6/=0/-7	+13/=0/-8	+12/=0/-1	+31/=1/-18	707	518	2.2226E-01	FALSE

S6 Complete median path plots for all the 24 path-planning algorithms for all the 50 models of the RP2B-24 library



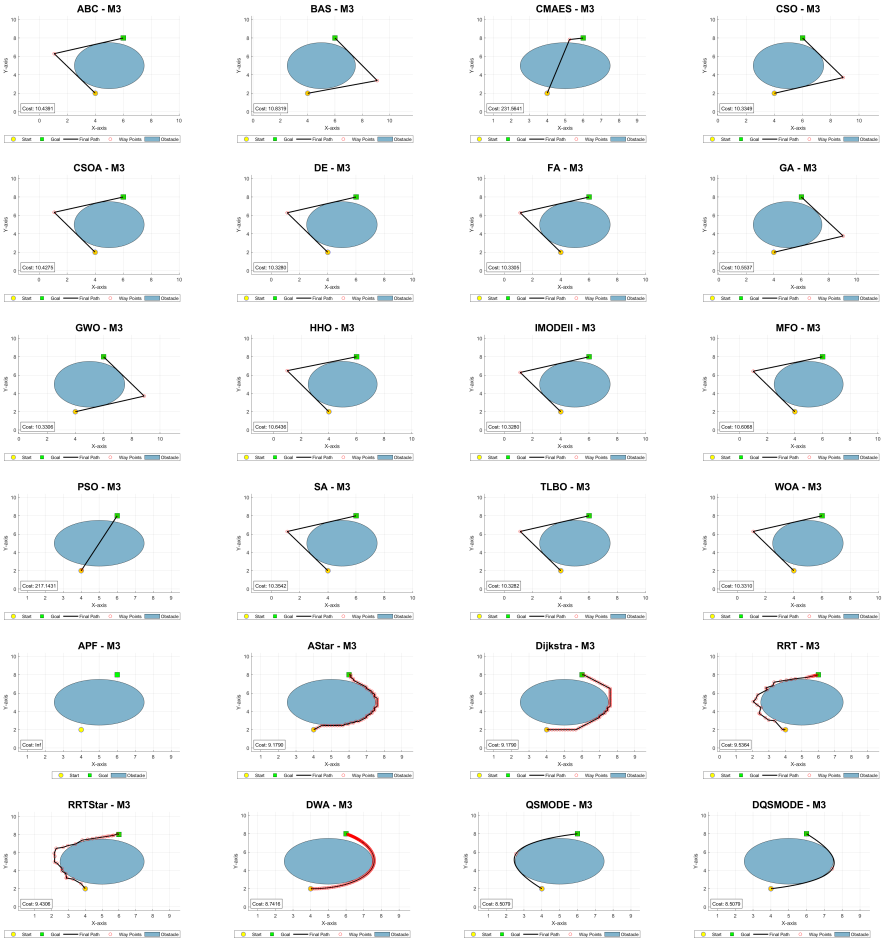
(1) M1 Model

Figure S13: Median Path plots for all the 24 path-planning algorithms.



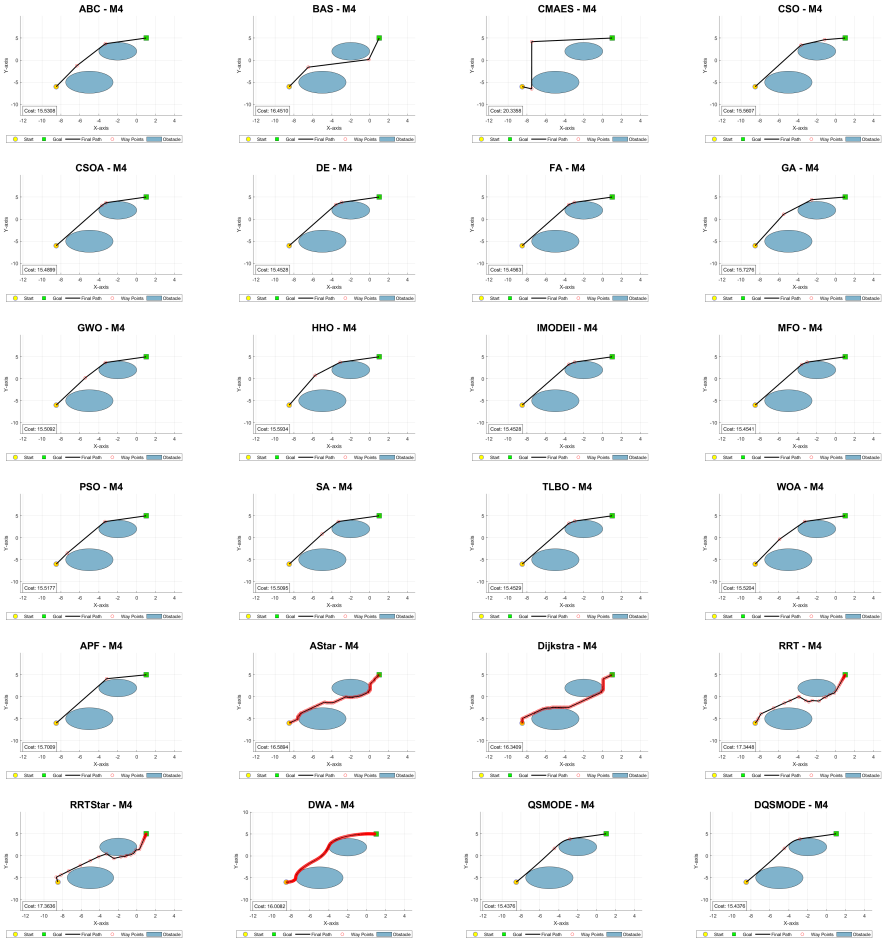
(2) M2 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(3) M3 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



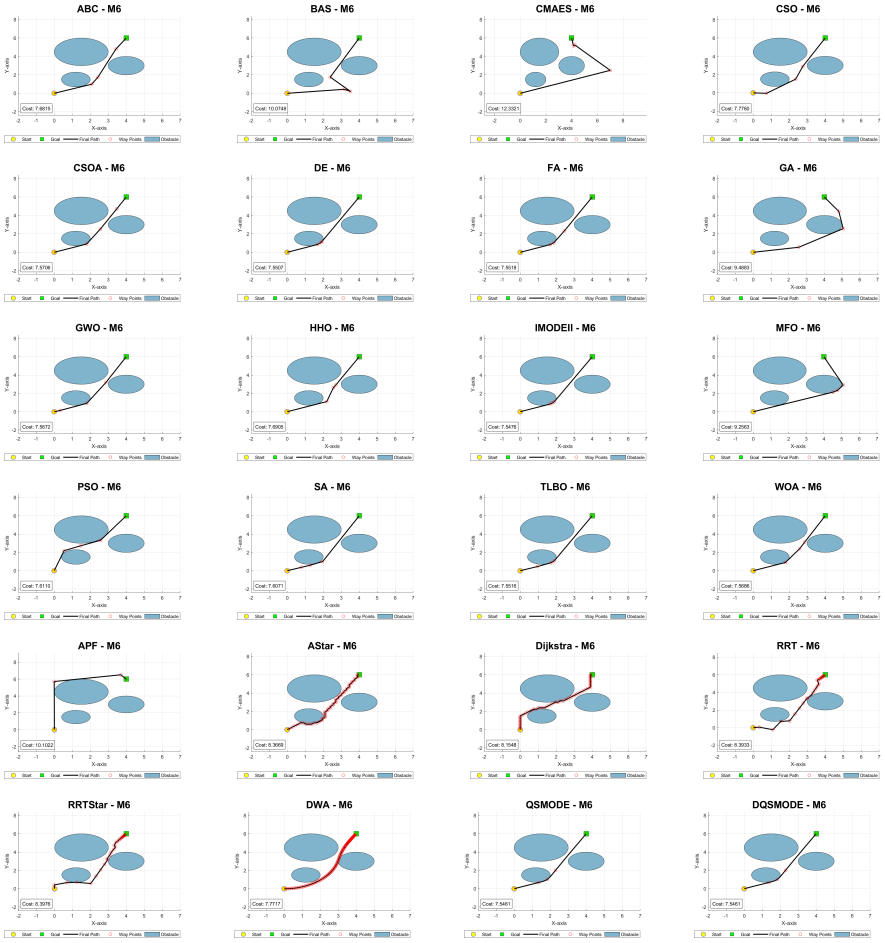
(4) M4 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



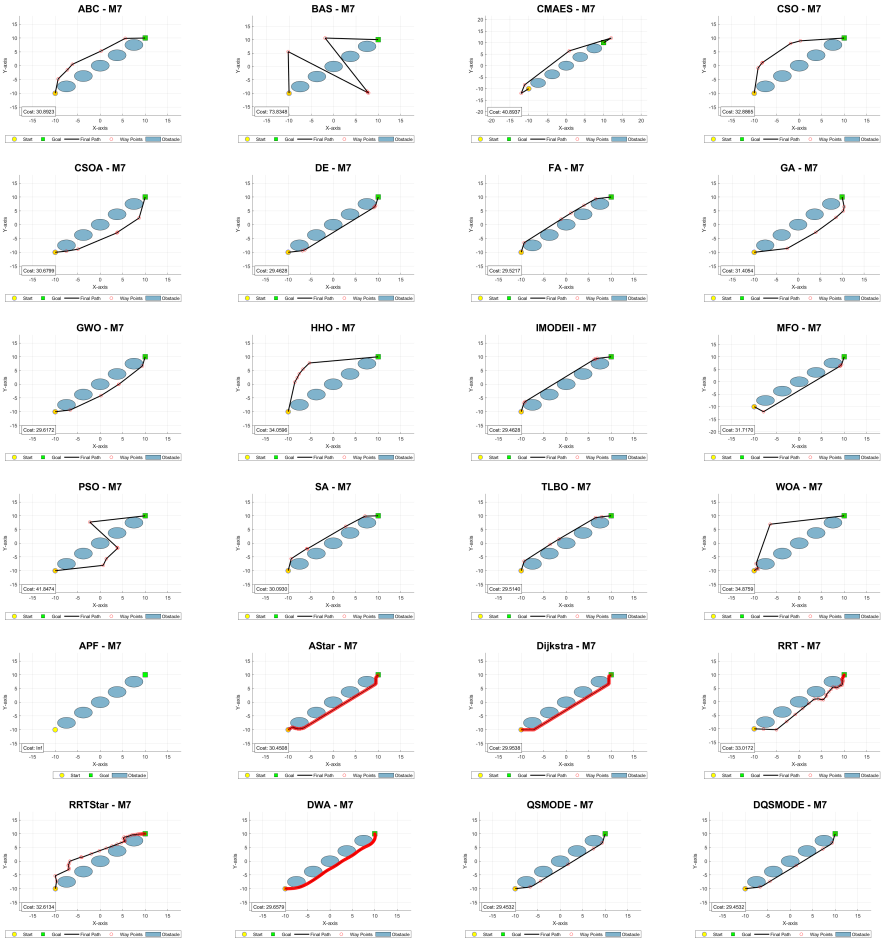
(5) M5 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(6) M6 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



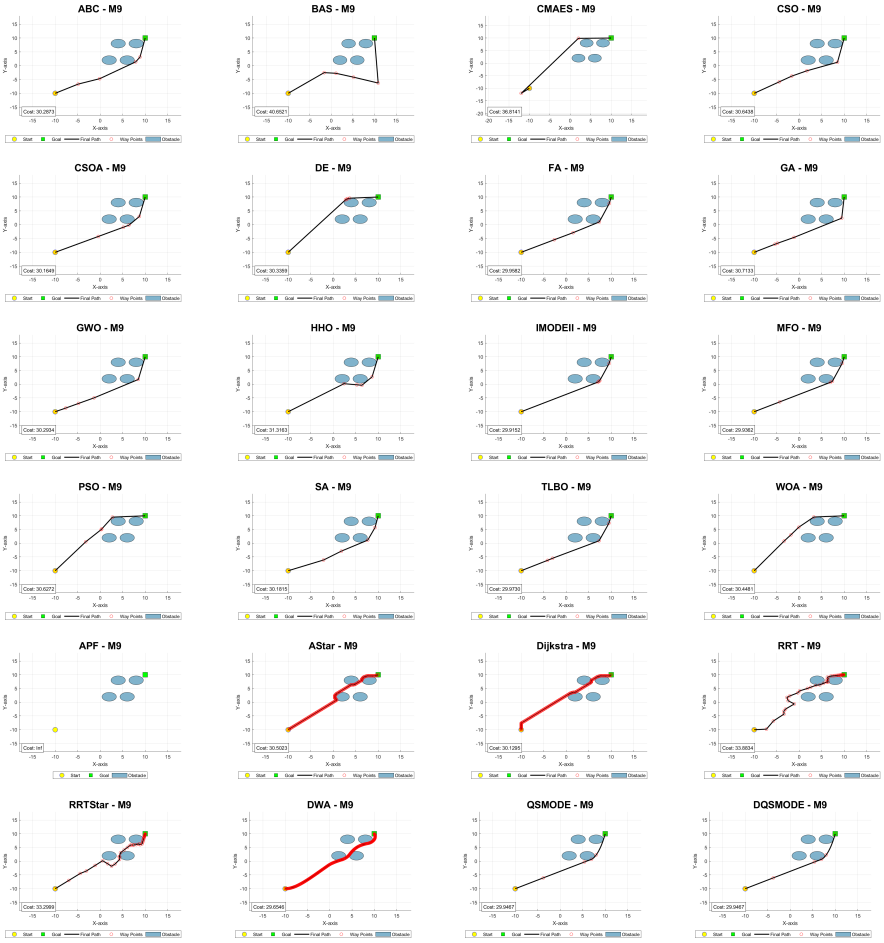
(7) M7 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



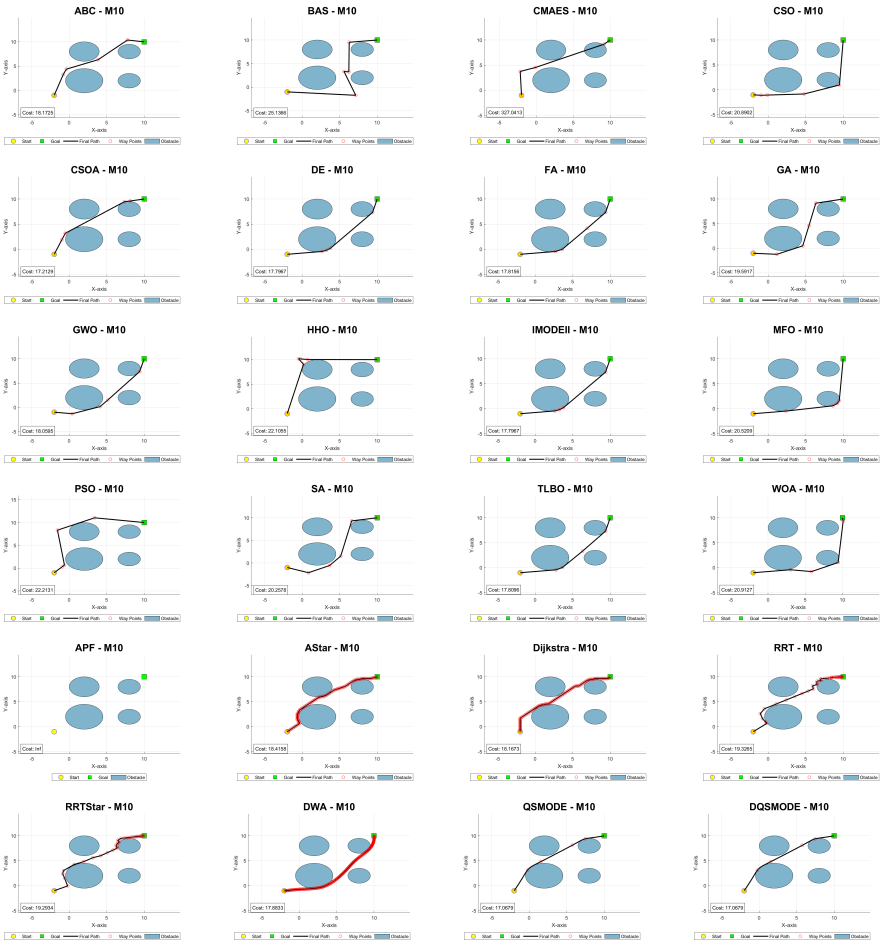
(8) M8 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(9) M9 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



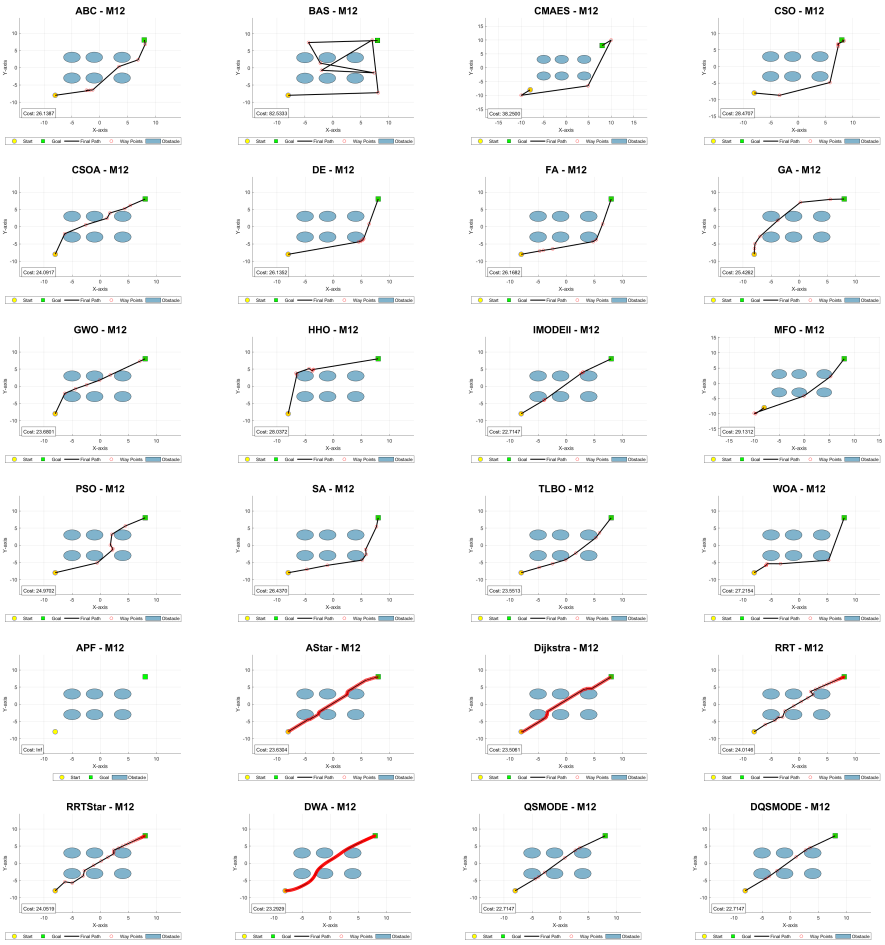
(10) M10 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



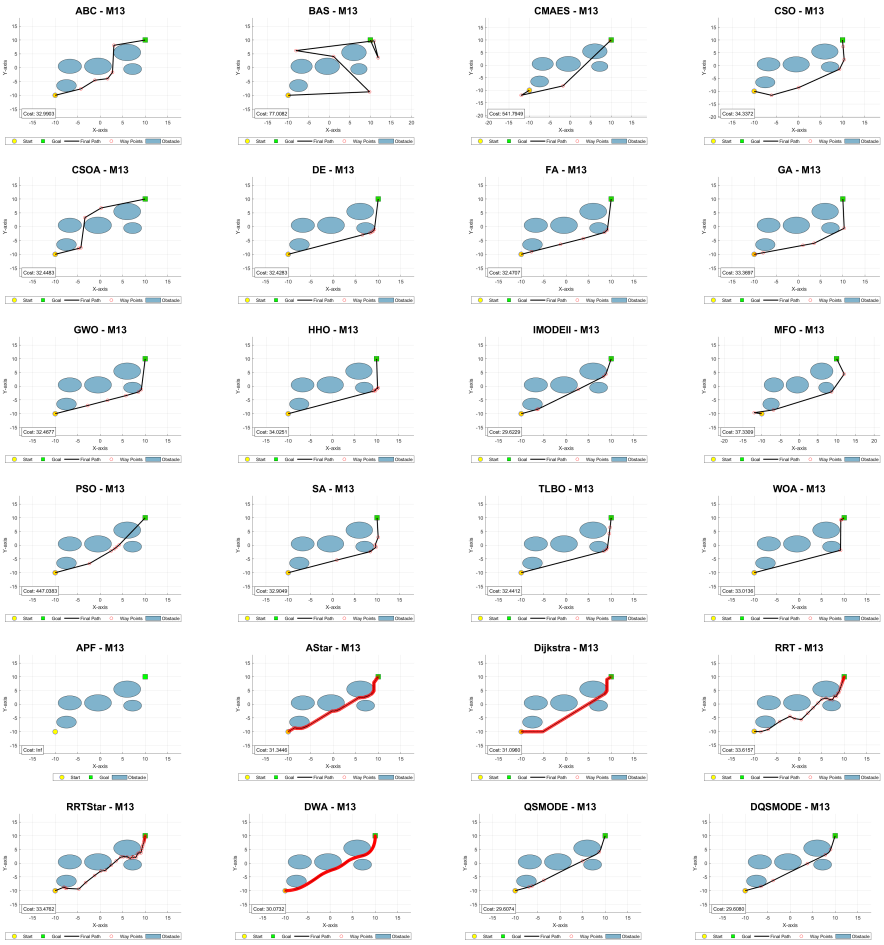
(11) M11 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(12) M12 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



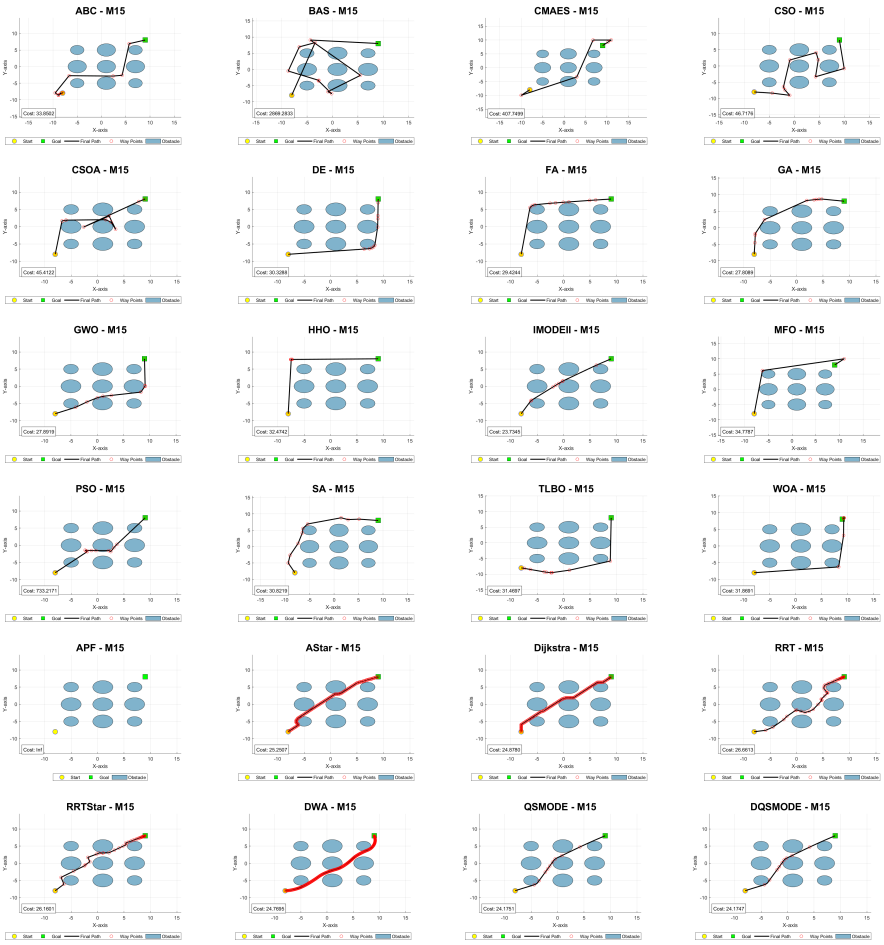
(13) M13 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



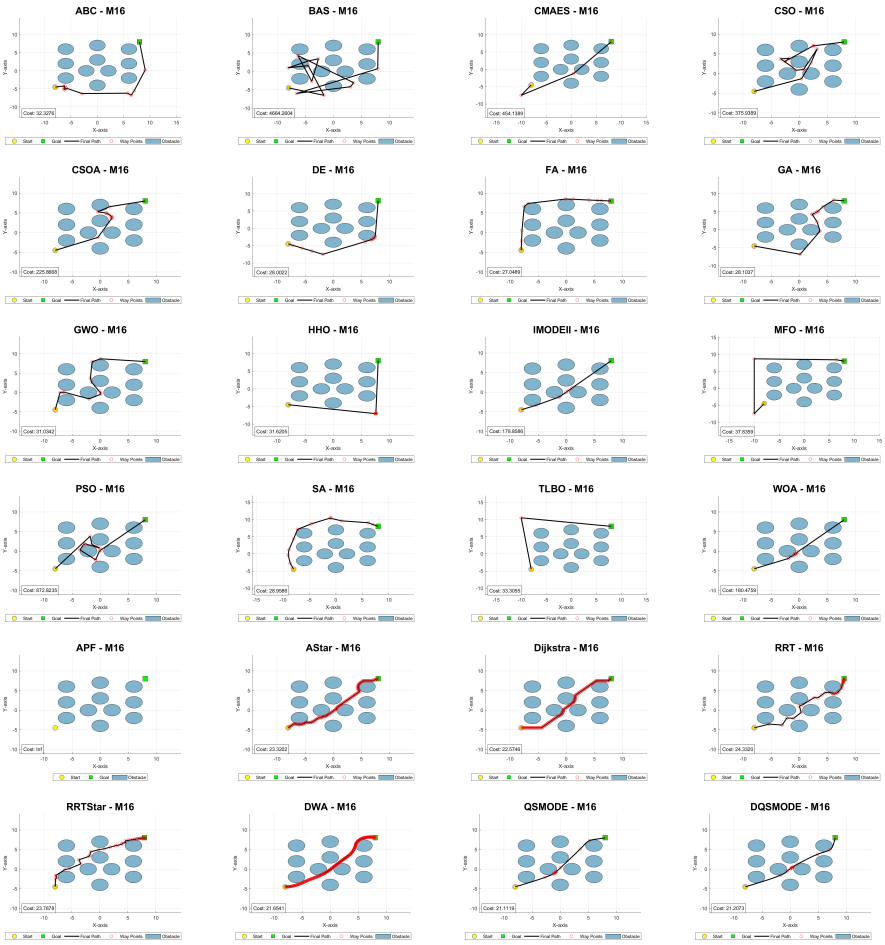
(14) M14 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(15) M15 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



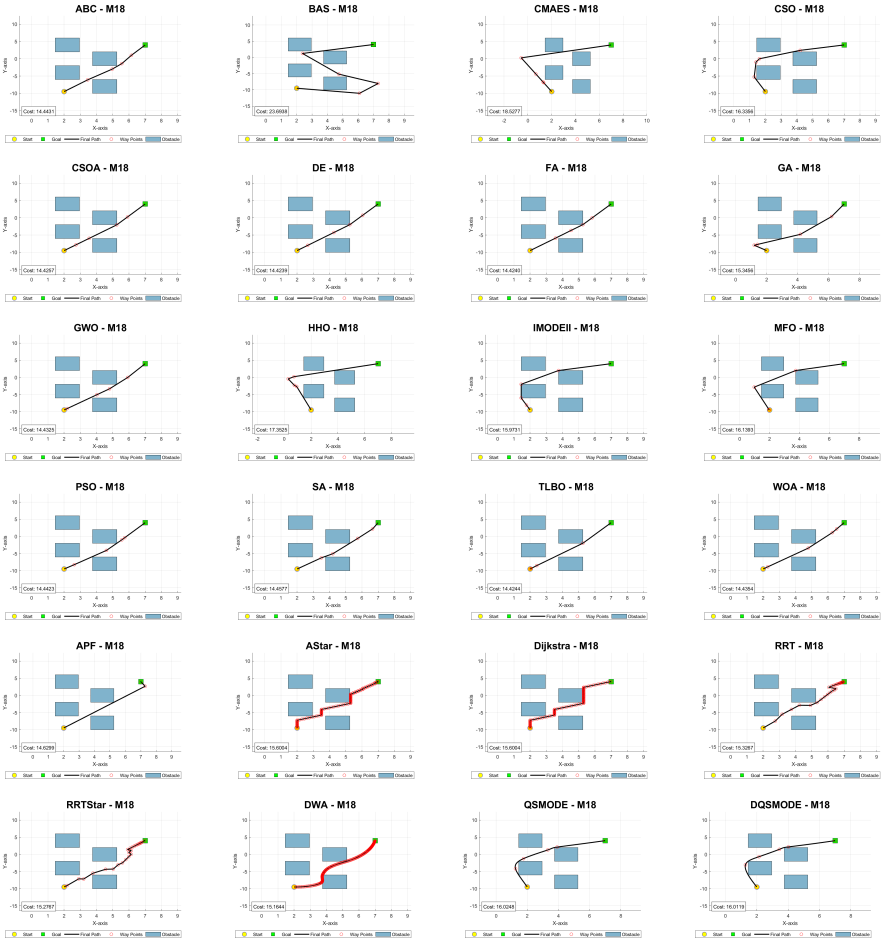
(16) M16 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(17) M17 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(18) M18 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(19) M19 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



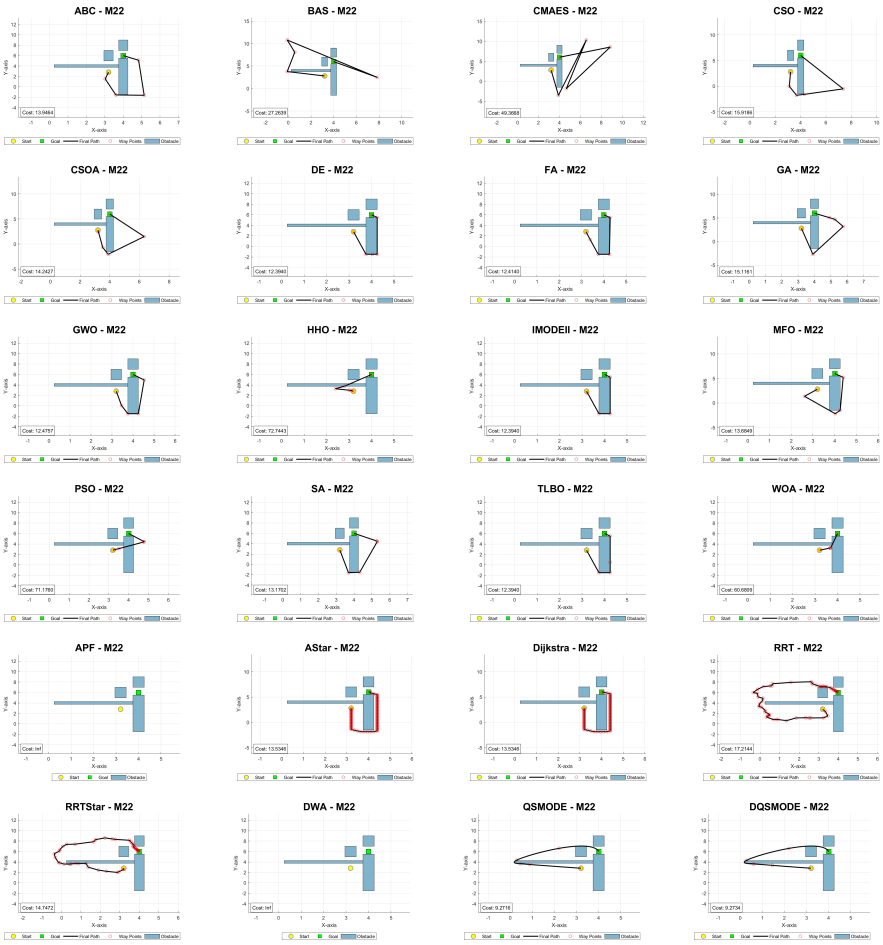
(20) M20 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



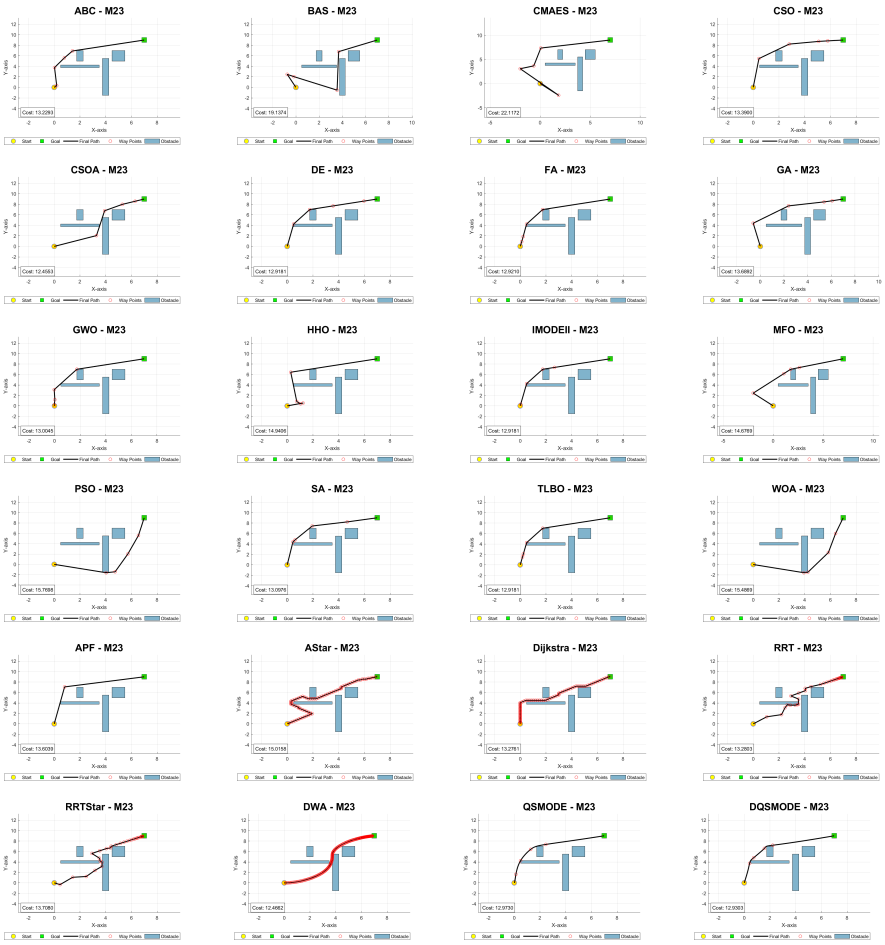
(21) M21 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



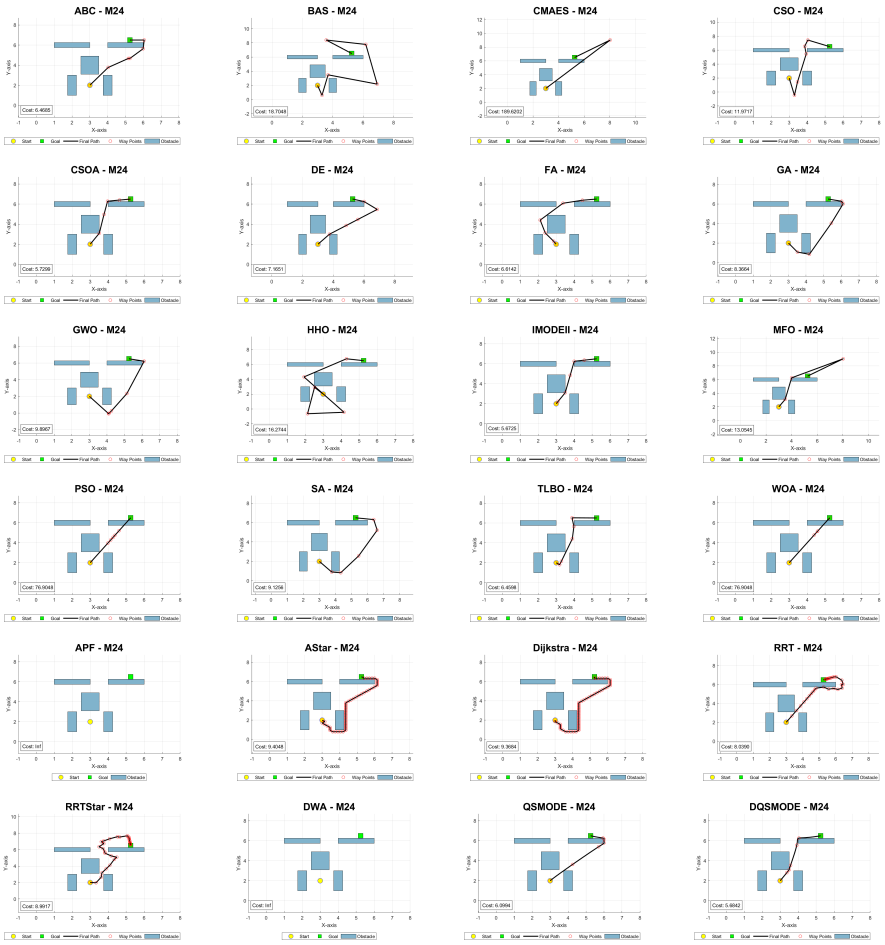
(22) M22 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(23) M23 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



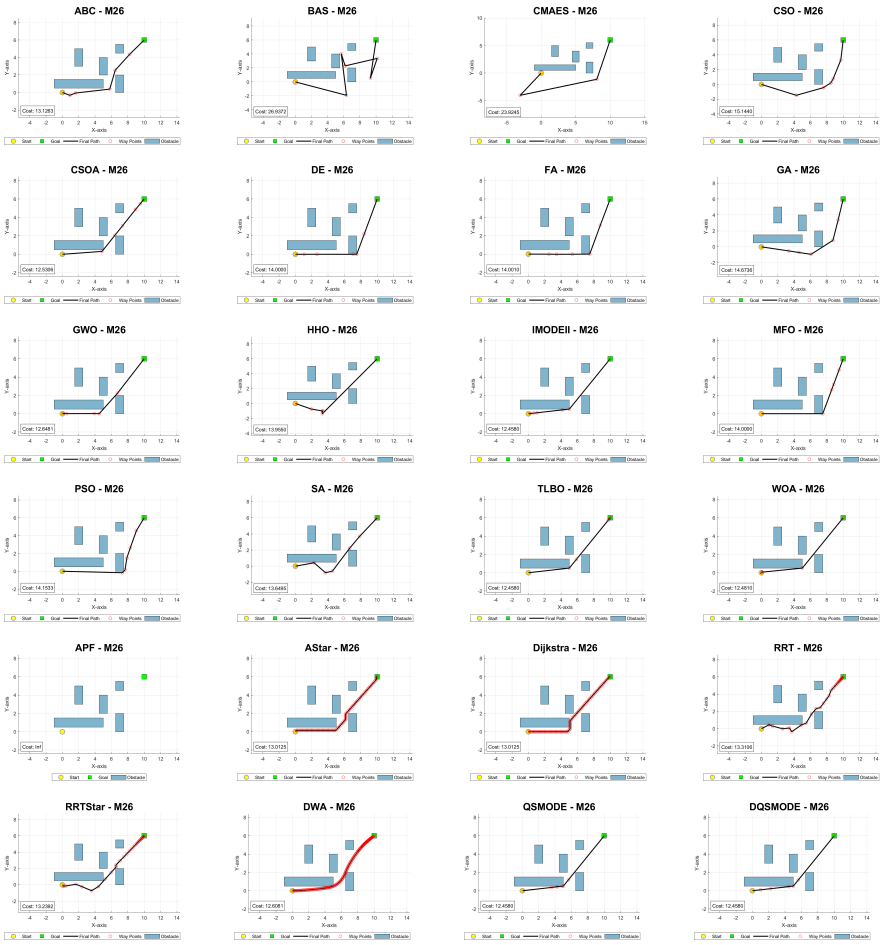
(24) M24 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(25) M25 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



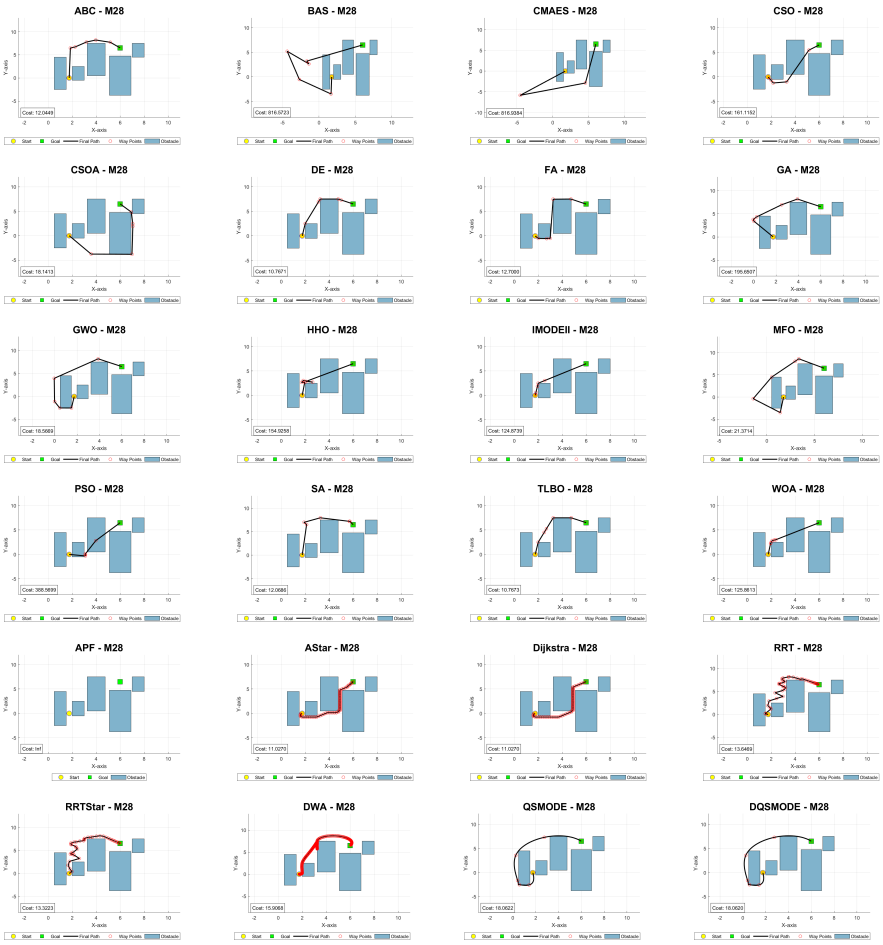
(26) M26 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



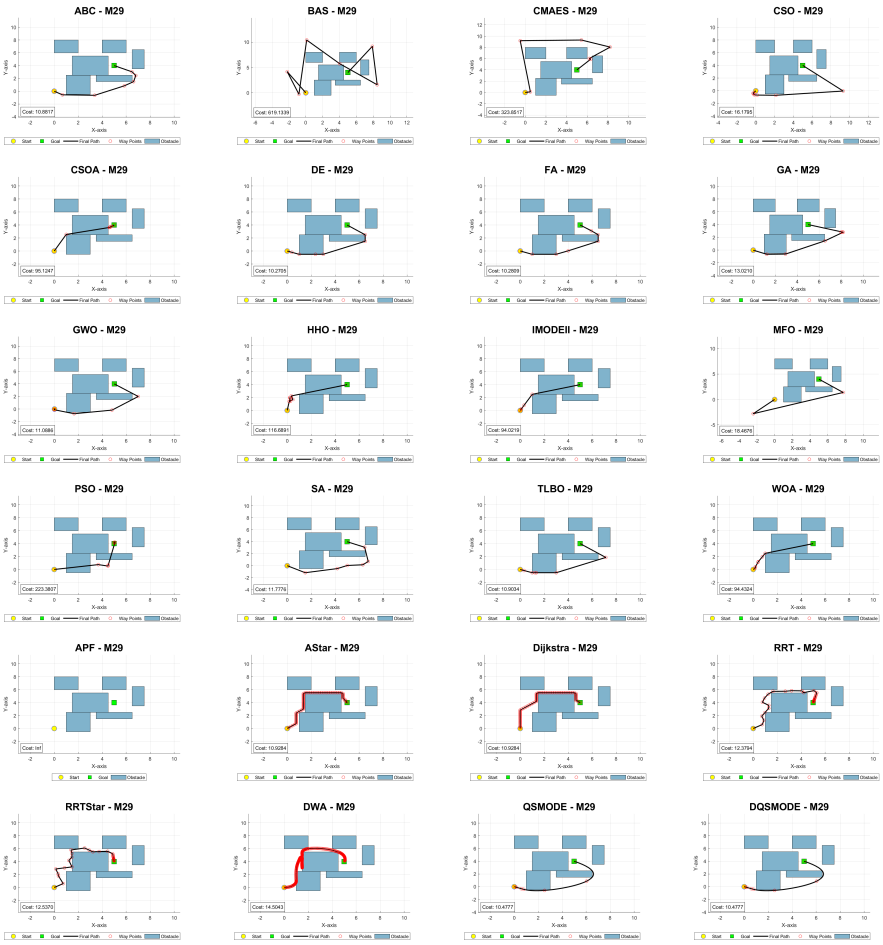
(27) M27 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(28) M28 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(29) M29 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(30) M30 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(31) M31 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(32) M32 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(33) M33 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(34) M34 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(35) M35 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



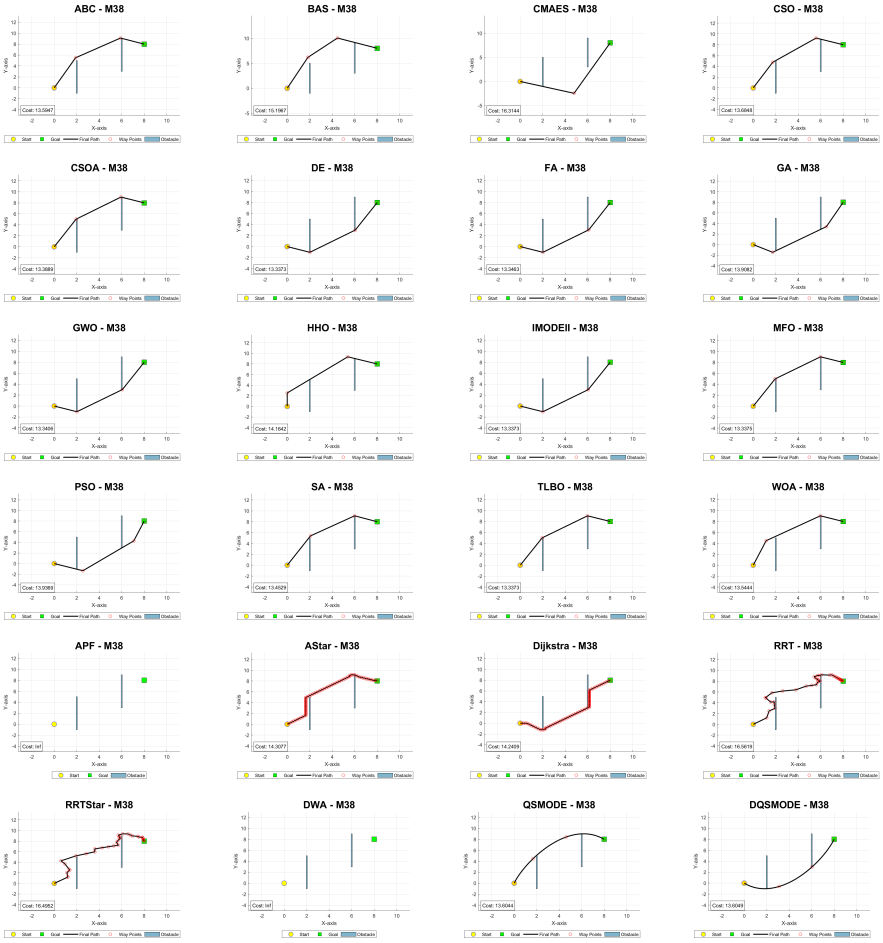
(36) M36 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



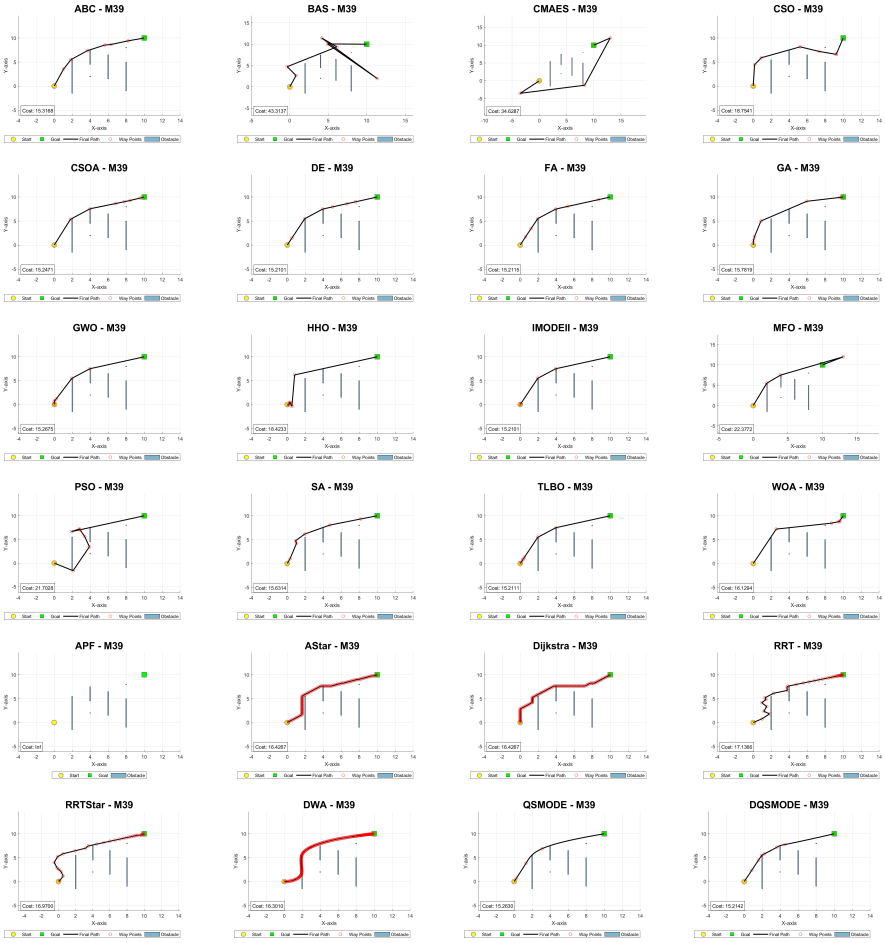
(37) M37 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



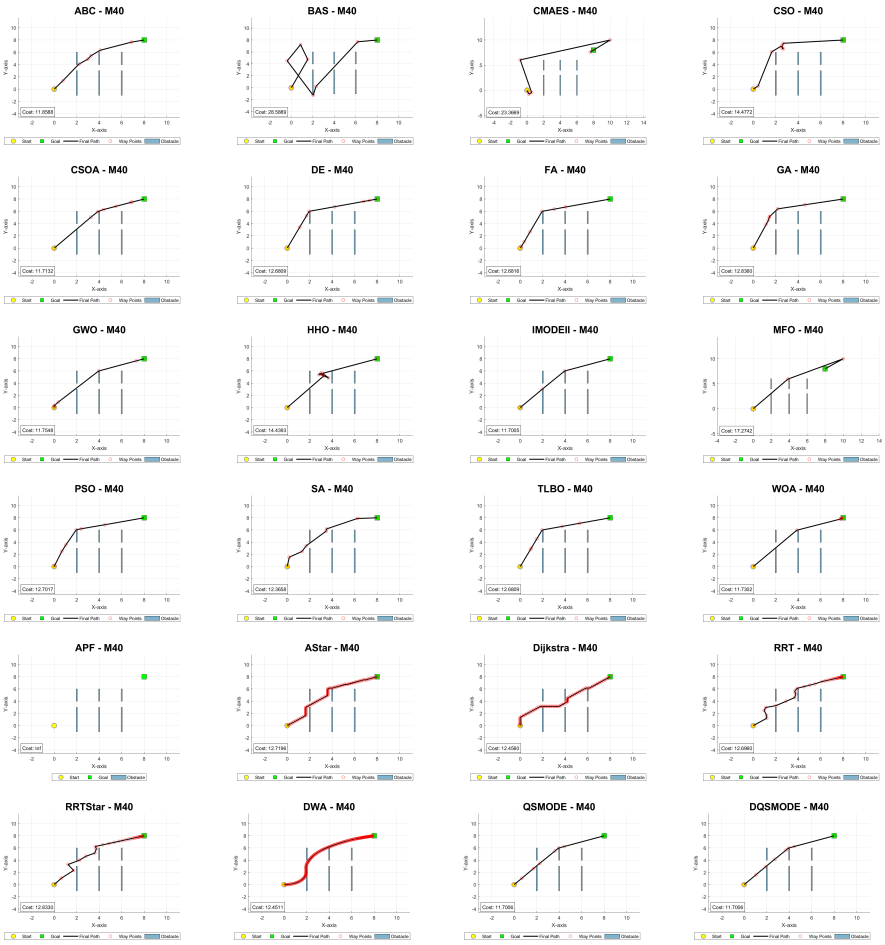
(38) M38 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(39) M39 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



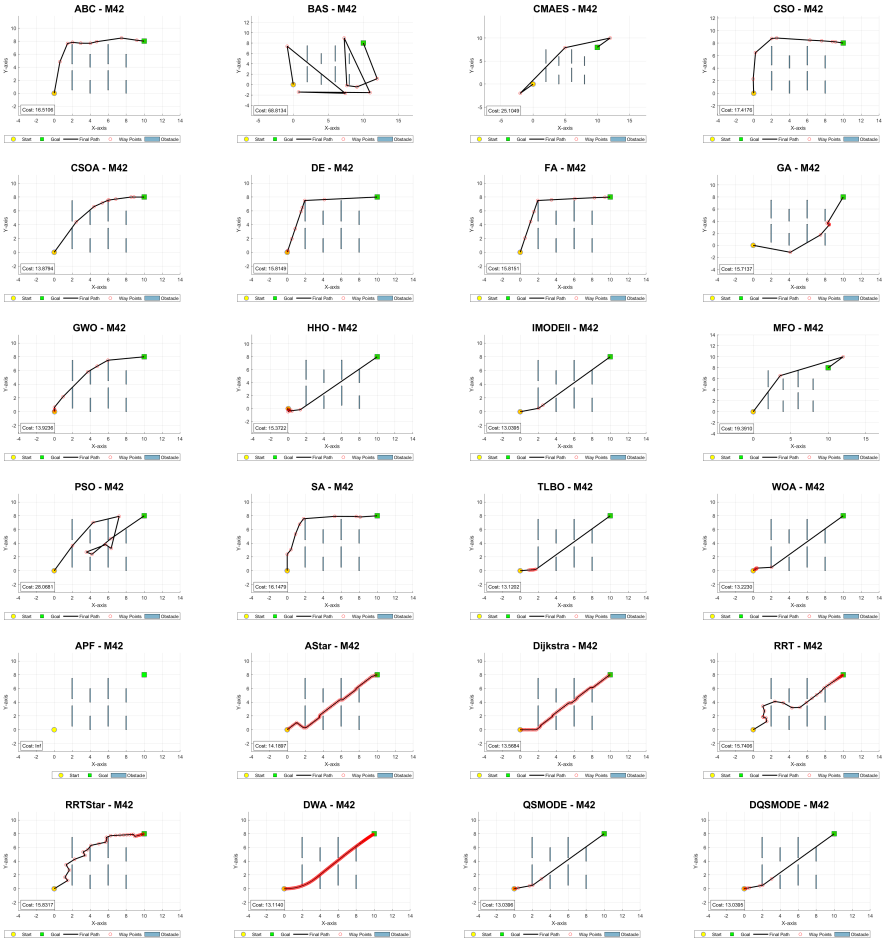
(40) M40 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



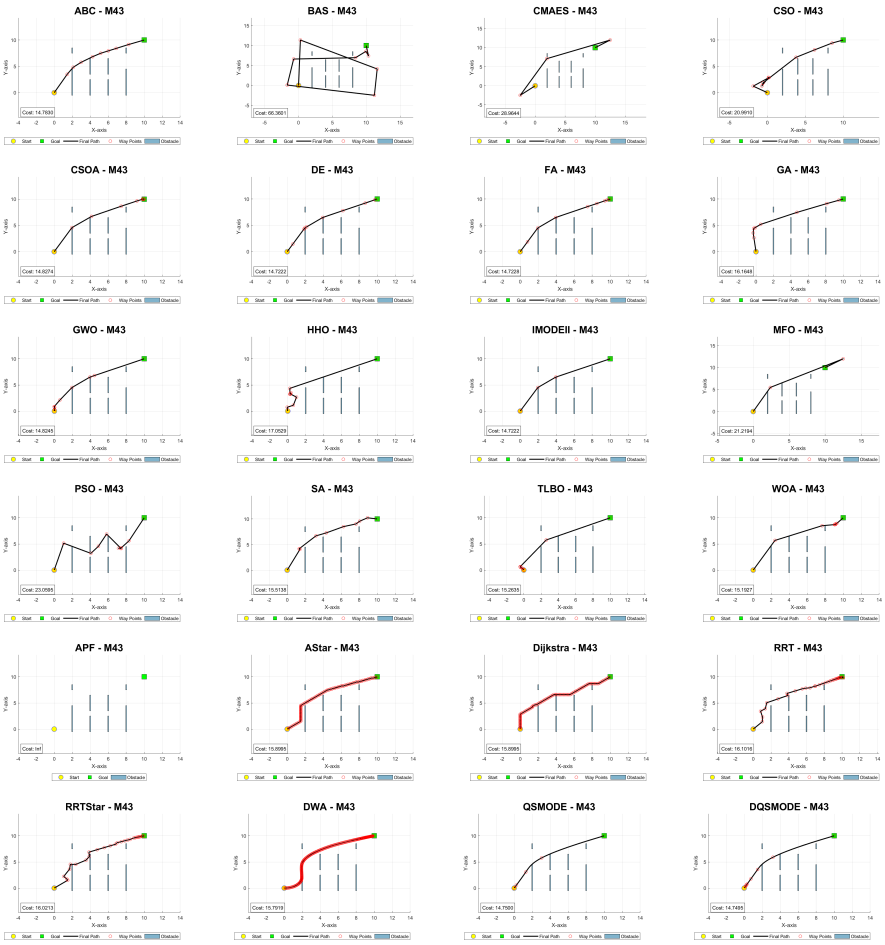
(41) M41 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



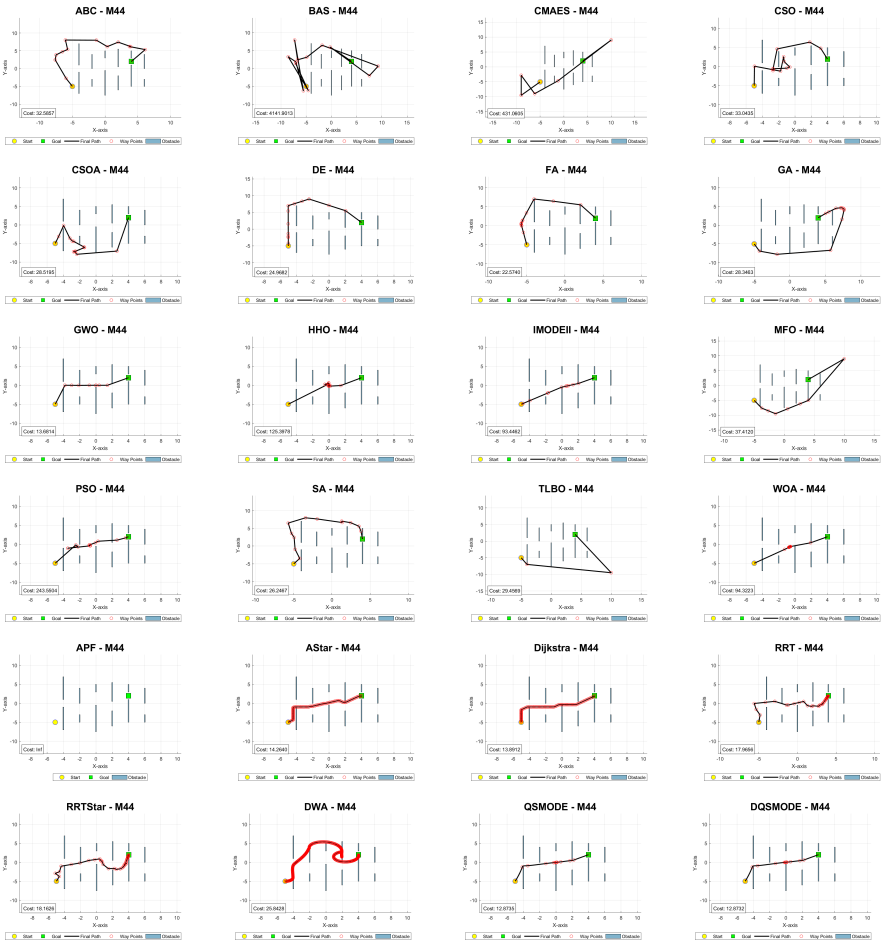
(42) M42 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



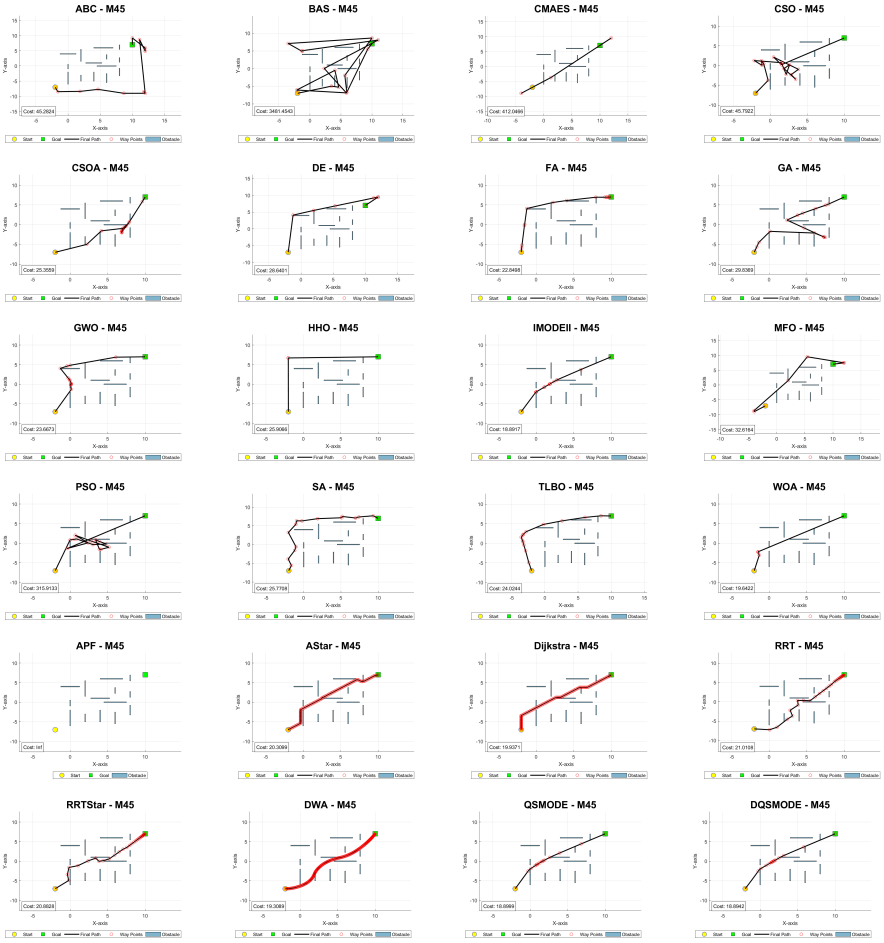
(43) M43 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



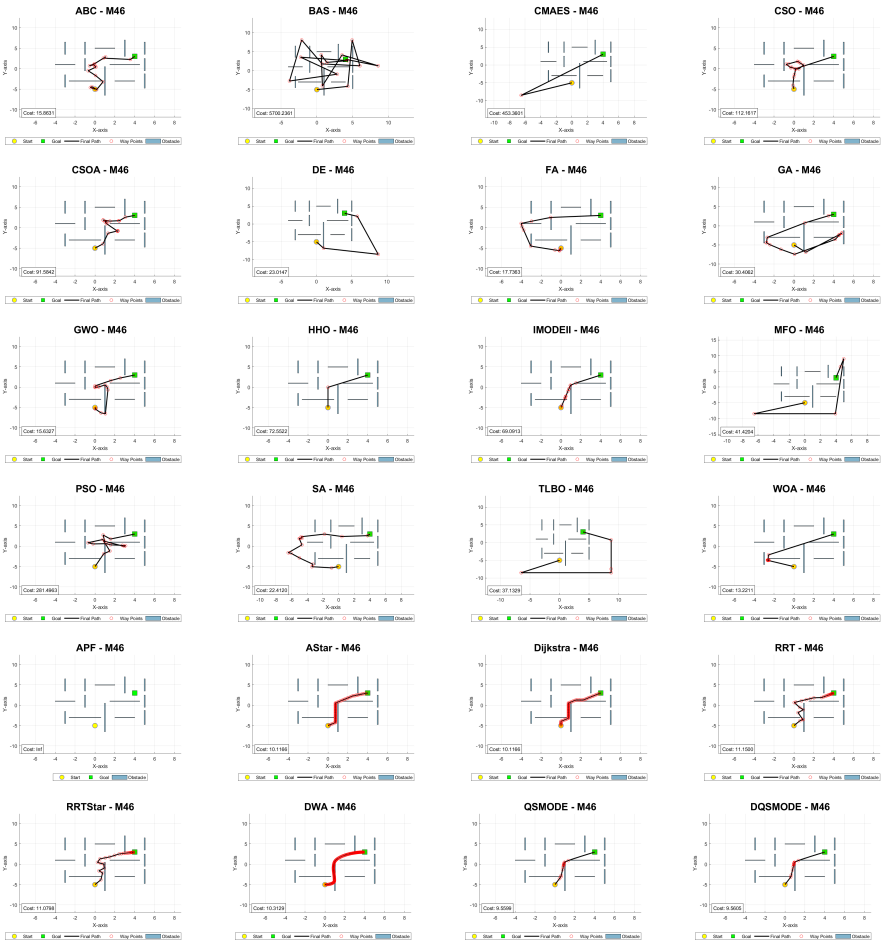
(44) M44 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



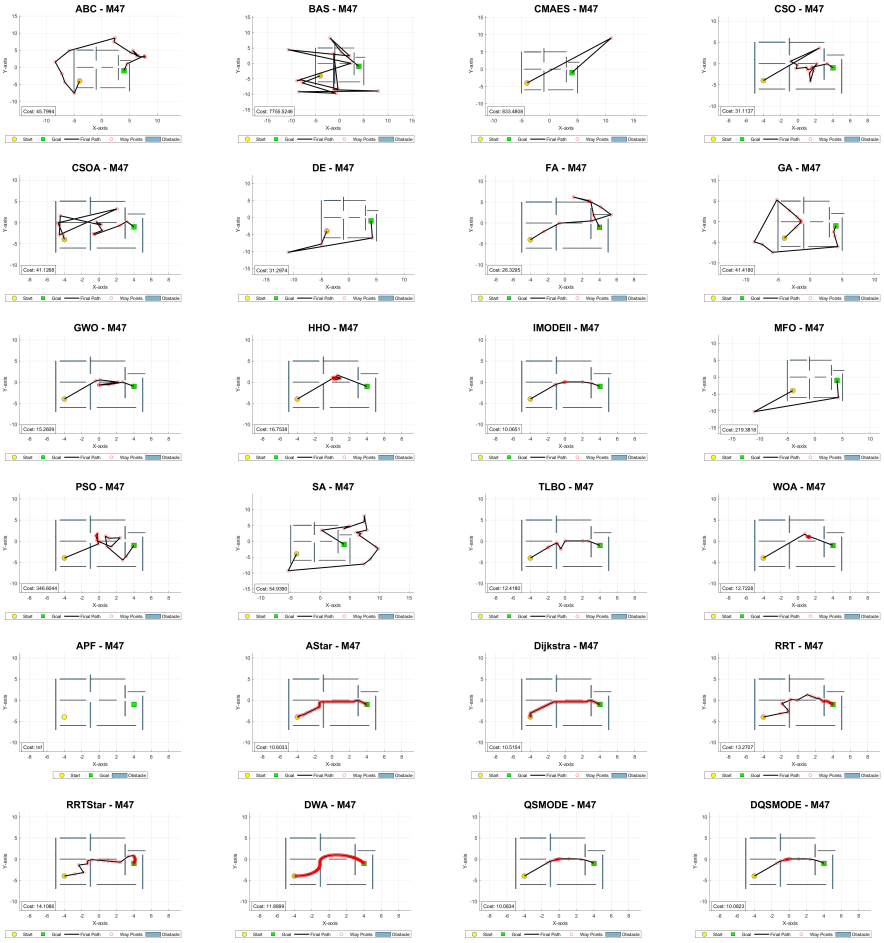
(45) M45 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



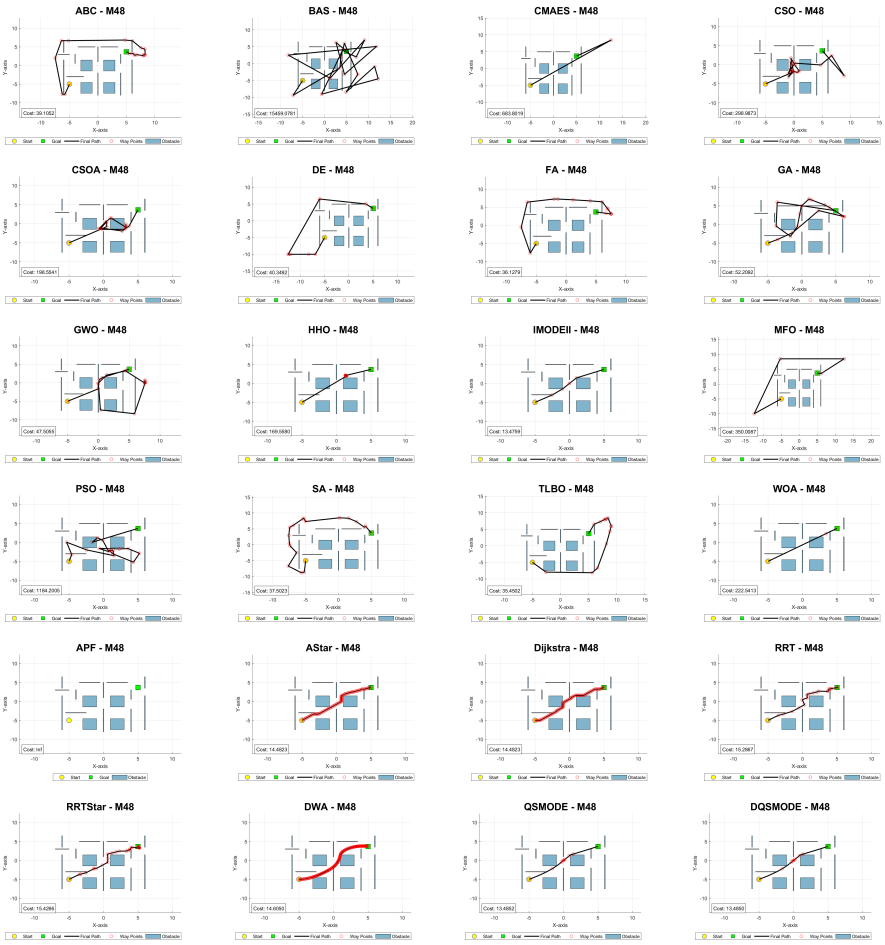
(46) M46 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



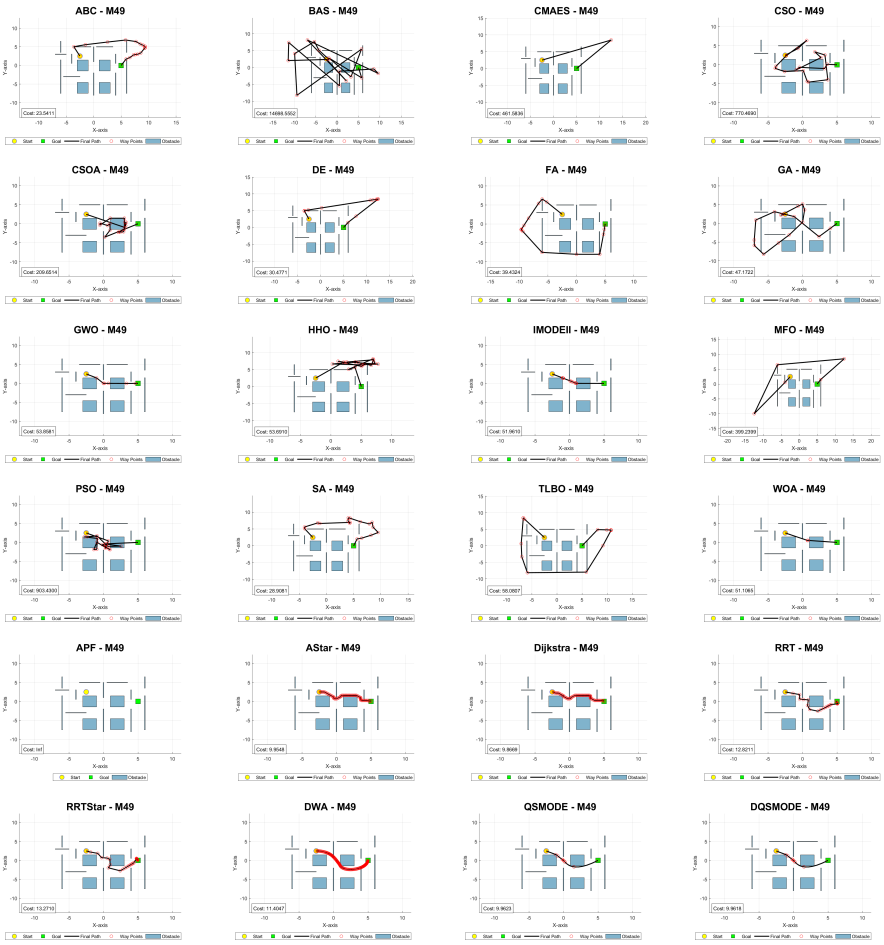
(47) M47 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



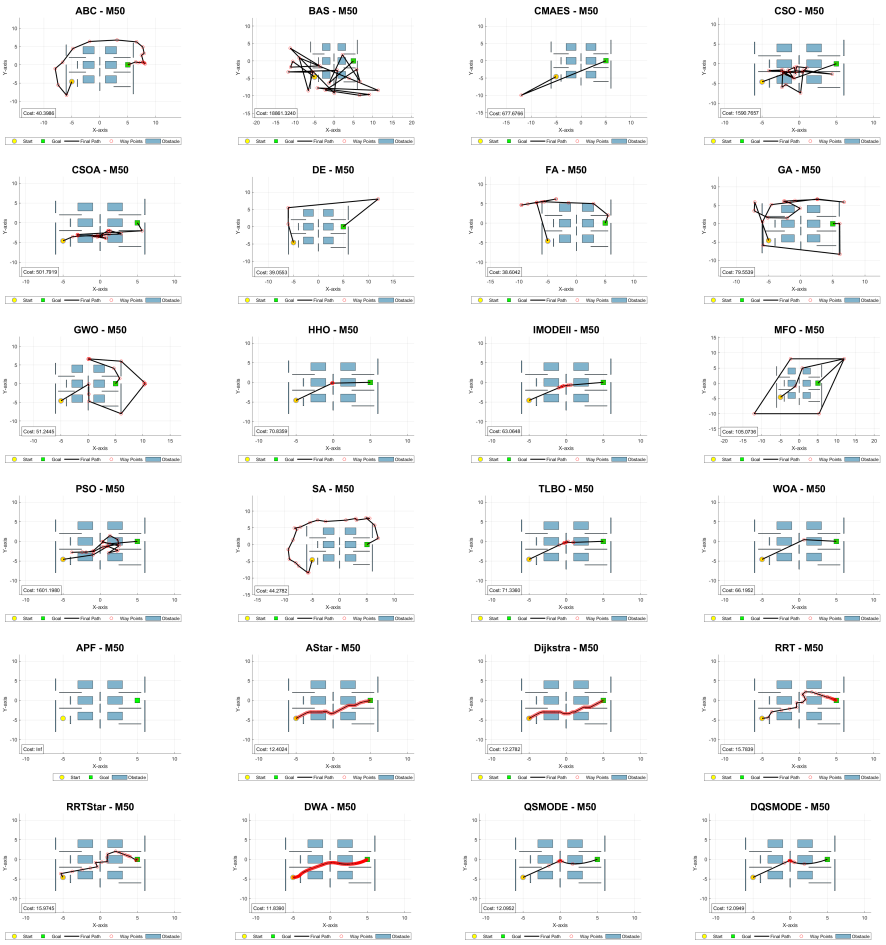
(48) M48 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(49) M49 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.



(50) M50 Model

Figure S13 (Cont.): Median Path plots for all the 24 path-planning algorithms.

References