

Supplementary Information

Theses supplementary materials contain 6 Tables and 1 Figure.

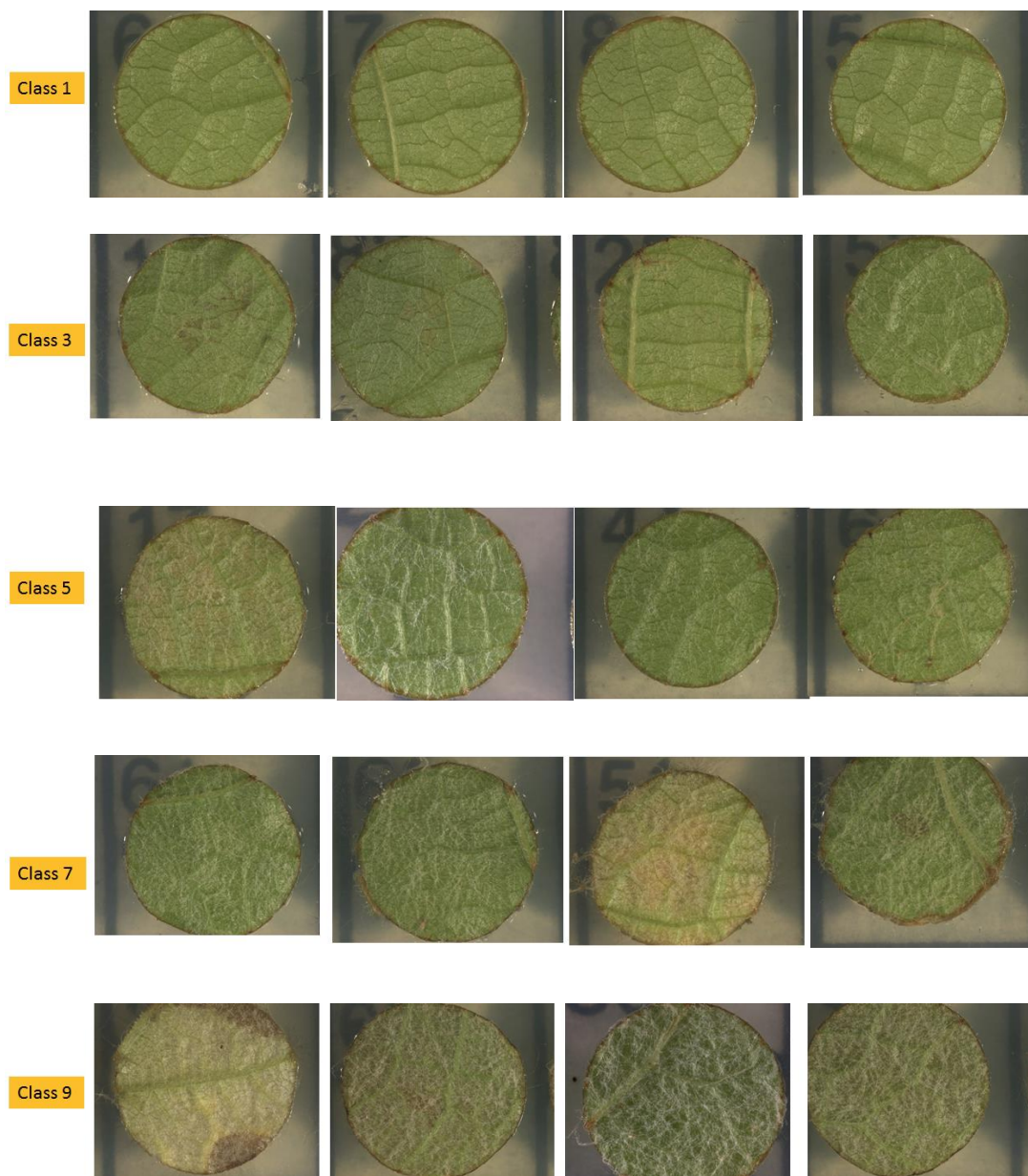
A high-throughput ResNet CNN approach for automated grapevine leaf hair quantification

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Supplementary Figure 1: Validation 1 (correlation of two experts and ResNet CNN): Leaf disc images used for the validation of the ResNet CNN model (four images for the five classes of the OIV leaf hair descriptor 086).

1 **Supplementary Table 1.** Grapevine accessions used, their metadata and their origin. VIVC=*Vitis* International Variety Catalogue
2 (<https://www.vivc.de>); V=*Vitis*;

Prime name	Variety number VIVC	Accession name	Accession number	Origin	Remarks
Morio Muskat	7996	Morio Muskat	DEU098-1980-037	JKI Siebeldingen	
COxGT2	27137	COXGT2	DEU098-2021-027	JKI Siebeldingen	<i>V. coignetiae</i> x Gewürztraminer hybrid
Cabernet Sauvignon	1929	Cabernet Sauvignon	DEU098-1990-015	JKI Siebeldingen	
Pinot Meunier	9278	Pinot Meunier	DEU098-1980-041	JKI Siebeldingen	
Regent	4572	Regent	DEU098-1980-701	JKI Siebeldingen	
Riesling Weiss	10077	Riesling Weiss Cl. 90	DEU098-1980-316	JKI Siebeldingen	
Tigvoasa	17114	Veltliner Braun	DEU098-1980-370	JKI Siebeldingen	
<i>V. thunbergii</i> x <i>V. vinifera</i>	NA	<i>V. ficifolia</i> Cl. GF1	DEU098-1980-774	JKI Siebeldingen	Putativ <i>V. thunbergii</i> x <i>V. vinifera</i> hybrid

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Supplementary Table 2: Validation 1: Single results of ResNet CNN (%) and experts evaluation of leaf discs; four images were analyzed for each of the five classes of OIV descriptor 086. Slice %: Slice classification ("background"/"Leaf with hair"/"Leaf without hair"). Manual %: Manual rating of leaf discs (0-100% leaf hair density)

		Leaf disc #1	Leaf disc #2	Leaf disc #3	Leaf disc #4
Class 1	ResNet CNN (%)	1	0.7	1.4	0.7
	Expert 1 (Slice %)	0	0	0	1
	Expert 2 (Slice %)	0	0	0	0
	Expert 1 (Manual %)	0	0	0	0
	Expert 2 (Manual %)	1	0	0	0
Class 3	ResNet CNN (%)	25.4	24.7	30.5	48.6
	Expert 1 (Slice %)	26	21	37	66
	Expert 2 (Slice %)	18	20	33	60
	Expert 1 (Manual %)	27	19	30	52
	Expert 2 (Manual %)	25	20	35	60
Class 5	ResNet CNN (%)	45.8	41	39.2	36.5
	Expert 1 (Slice %)	68	40	48	54
	Expert 2 (Slice %)	75	50	50	50
	Expert 1 (Manual %)	60	33	40	60
	Expert 2 (Manual %)	70	45	50	55
Class 7	ResNet CNN (%)	87.2	89.8	20	92.2
	Expert 1 (Slice %)	90	90	28	92
	Expert 2 (Slice %)	90	92	85	93
	Expert 1 (Manual %)	79	79	60	88
	Expert 2 (Manual %)	90	90	85	92
Class 9	ResNet CNN (%)	37	94.1	96.7	97.1
	Expert 1 (Slice %)	33	97	99	99
	Expert 2 (Slice %)	96	98	97	99
	Expert 1 (Manual %)	73	87	94	97
	Expert 2 (Manual %)	90	98	96	100

Supplementary Table 3: Validation 2: Summary of ResNet CNN (%) vs. panel of evaluations of six genotype leaf discs from two experts and non-experts. Slice %: Slice classification ("background"/"Leaf with hair"/"Leaf without hair"). Manual %: Manual rating of leaf discs (0-100% leaf hair density)

		Genotypes with hairy leaves			Genotypes with non-hairy leaves		
		<i>V. thunbergii</i> x <i>V. vinifera</i>	Tigvoasa	Pinot Meunier	Riesling	Regent	Cabernet Sauvignon
	ResNet CNN (%)	60.0	68,4	89	0	0.4	2.2
Evaluator 1	Expert 1 (Slice %)	58.9	72.2	95	0	0	1.8
Evaluator 2	Expert 2 (Slice %)	61	71.2	97	0	0	1.5
Evaluator 1	Expert 1 (Manual %)	60	70	92	0	0	0
Evaluator 2	Expert 2 (Manual %)	58	65	92	0	0	0
Evaluator 1	Non-expert 1 (Slice %)	86	93	96	11	3	31
Evaluator 2	Non-expert 2 (Slice %)	91	98	99	0	0	22
Evaluator 1	Non-expert 1 (Manual %)	10	30	80	0	0	1
Evaluator 2	Non-expert 2 (Manual %)	15	25	82	0	0	2

15 **Supplementary Table 4:** Validation 2: Absolute error (AE) calculation. ResNet CNN
16 represents true values. AE Slice represents estimated values for Slice (%)
17 classification. AE manual represents estimated values for manual rating (%).
18 Evaluators were two experts and two non-experts.

Genotypes	ResNet CNN	AE Slice	AE Manual	Evaluators
<i>V. thunbergii</i> x <i>V. vinifera</i>	60	-1.1	0	Expert 1
Tigvoasa	68.4	4.1	1.6	Expert 1
Pinot Meunier	89	6	3	Expert 1
Riesling	0	0	0	Expert 1
Regent	0.4	-0.4	-0.4	Expert 1
Cabernet Sauvignon	2.2	-0.4	-2.2	Expert 1
<i>V. thunbergii</i> x <i>V. vinifera</i>	60	1	-2	Expert 2
Tigvoasa	68.4	2.8	-3.4	Expert 2
Pinot Meunier	89	8	3	Expert 2
Riesling	0	0	0	Expert 2
Regent	0.4	-0.4	-0.4	Expert 2
Cabernet Sauvignon	2.2	-0.7	-2.2	Expert 2
<i>V. thunbergii</i> x <i>V. vinifera</i>	60	26.7	-50	Non-expert 1
Tigvoasa	68.4	24.5	-38.4	Non-expert 1
Pinot Meunier	89	7.4	-9	Non-expert 1
Riesling	0	11	0	Non-expert 1
Regent	0.4	2.6	-0.4	Non-expert 1
Cabernet Sauvignon	2.2	29	-1.2	Non-expert 1
<i>V. thunbergii</i> x <i>V. vinifera</i>	60	31.5	-45	Non-expert 2
Tigvoasa	68.4	29.3	-43.4	Non-expert 2
Pinot Meunier	89	9.5	-7	Non-expert 2
Riesling	0	0	0	Non-expert 2
Regent	0.4	-0.4	-0.4	Non-expert 2
Cabernet Sauvignon	2.2	19.8	-0.2	Non-expert 2

Supplementary Table 5: Validation 3: Summary of audience manual rating of six genotypes. Genotypes with non-hairy leaves: ‘Riesling’, ‘Cabernet Sauvignon’ and ‘Regent’. Genotypes with hairy leaves: ‘Tigvoasa’, ‘Pinot Meunier’ and *V. thunbergii* x *V. vinifera*.

	Riesling	Pinot Meunier	Cabernet Sauvignon	Tigvoasa	Regent	<i>V. thunbergii</i> x <i>V. vinifera</i>
ResNet CNN %	0	89	2.2	68.4	0.4	60
Evaluator 1	0	80	2	15	0	20
Evaluator 2	0	100	10	80	0	50
Evaluator 3	1	70	0	20	0	10
Evaluator 4	0	70	5	25	0	15
Evaluator 5	20	80	30	50	15	70
Evaluator 6	0	100	0	30	0	10
Evaluator 7	20	100	20	0	20	50
Evaluator 8	0	96	0	63	0	52
Evaluator 9	0	75	0	5	0	2
Evaluator 10	0	80	7	20	5	27
Evaluator 11	0	80	10	20	0	40
Evaluator 12	0	90	5	40	0	20
Evaluator 13	10	90	25	50	20	35
Evaluator 14	0	80	0	40	20	30
Evaluator 15	0.5	98	5	25	3	30
Evaluator 16	0	98	0	50	0	30

Supplementary Table 6: Validation 3: Absolute error estimation of audience validation.

	Riesling	Pinot Meunier	Cabernet Sauvignon	Tigvoasa	Regent	<i>V. thunbergii</i> x <i>V. vinifera</i>
Evaluator 1	0	-19	-0.2	-68.4	-0.4	-8
Evaluator 2	0	-19	-0.2	-63.4	-0.4	-10
Evaluator 3	0	-14	-0.2	-53.4	-0.4	-10
Evaluator 4	0	-9	-0.2	-48.4	-0.4	-20
Evaluator 5	0	-9	-0.2	-48.4	-0.4	-25
Evaluator 6	0	-9	-0.2	-48.4	-0.4	-30
Evaluator 7	0	-9	1.8	-43.4	-0.4	-30
Evaluator 8	0	-9	4.8	-43.4	-0.4	-30
Evaluator 9	0	1	4.8	-38.4	-0.4	-33
Evaluator 10	0	1	4.8	-28.4	-0.4	-40
Evaluator 11	0	7	6.8	-28.4	2.6	-40
Evaluator 12	0	9	9.8	-18.4	4.6	-45
Evaluator 13	1	9	9.8	-18.4	14.6	-50
Evaluator 14	10	11	19.8	-18.4	19.6	-50
Evaluator 15	20	11	24.8	-5.4	19.6	-58
Evaluator 16	20	11	29.8	11.6	19.6	10