

ProtoPairNet: Interpretable Regression through Prototypical Pair Reasoning

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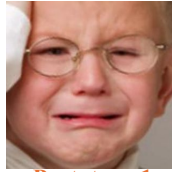
^c Dartmouth College

^d Yale University

Reasoning with one-to-one comparison:



Input Image
Original age 26

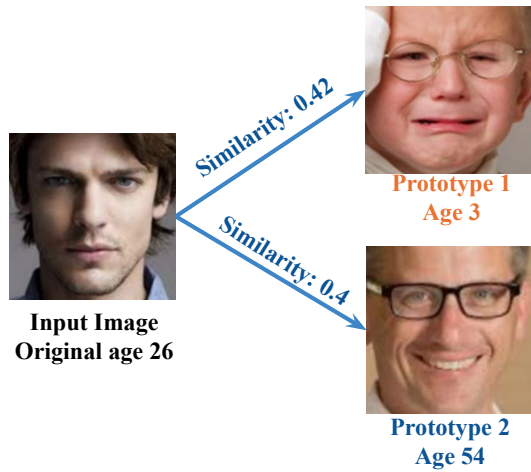


Prototype 1
Age 3

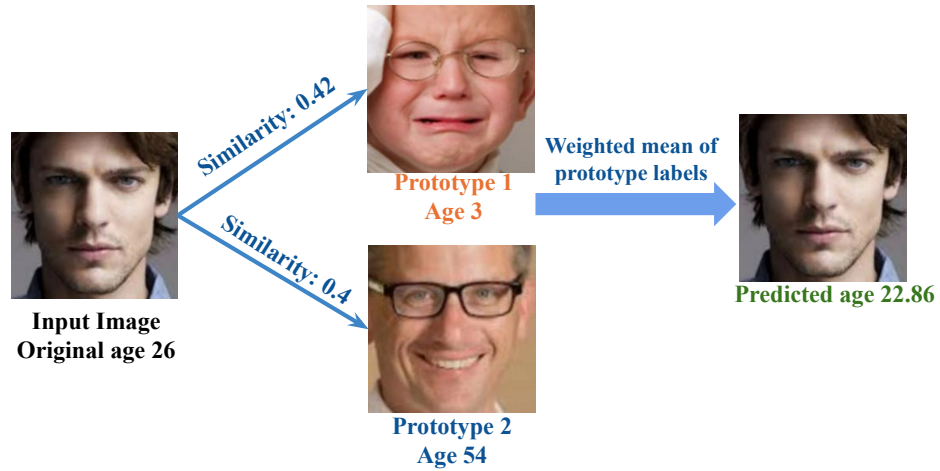


Prototype 2
Age 54

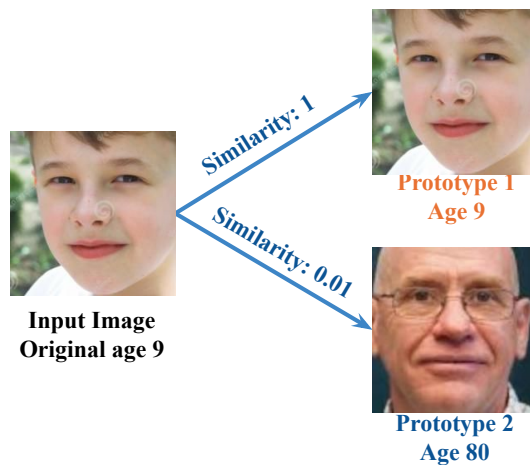
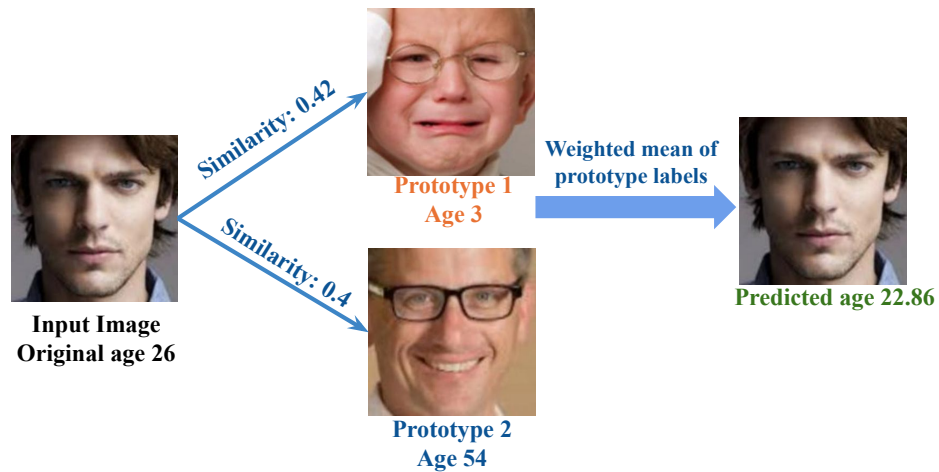
Reasoning with one-to-one comparison:



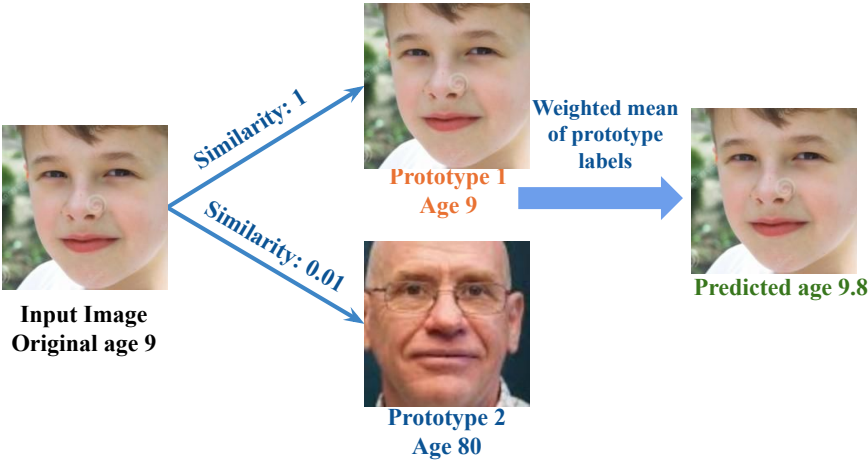
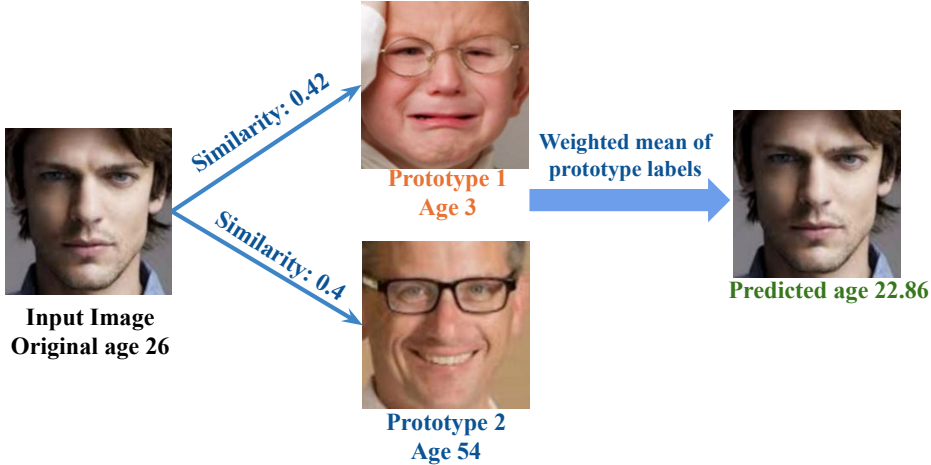
Reasoning with one-to-one comparison:



Reasoning with one-to-one comparison:

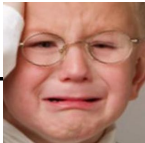


Reasoning with one-to-one comparison:



Reasoning with Prototypical pair:

Age varies
linearly
along this
line

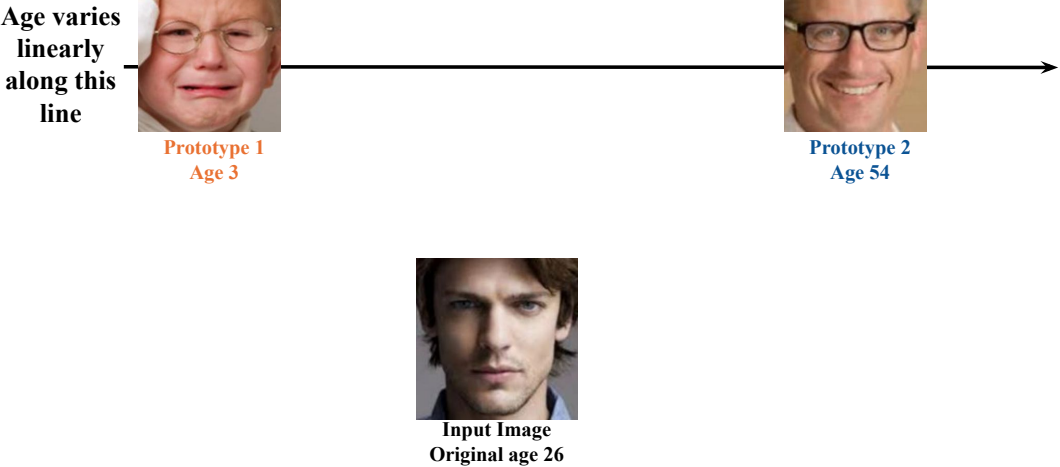


Prototype 1
Age 3

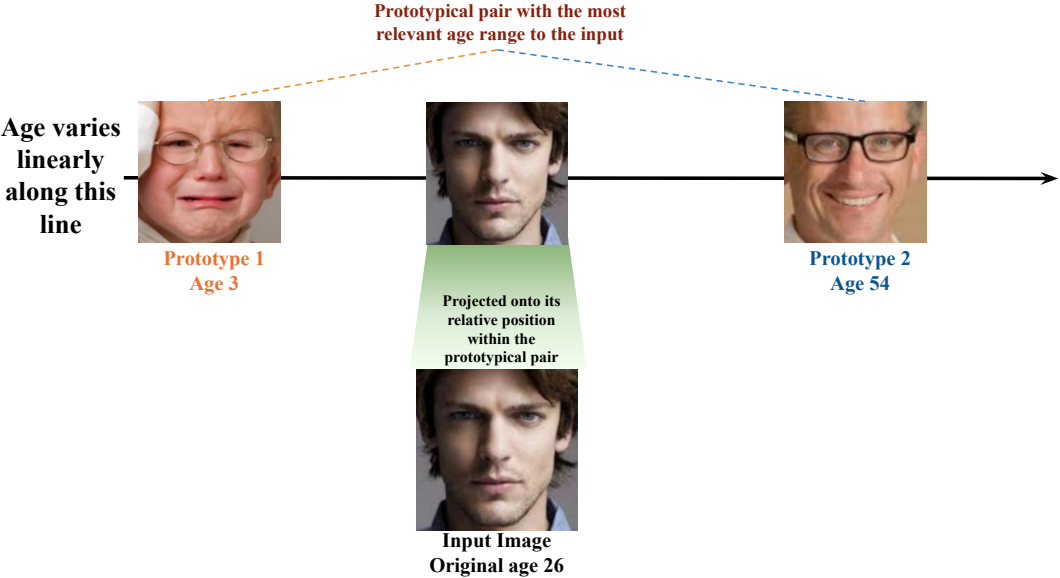


Prototype 2
Age 54

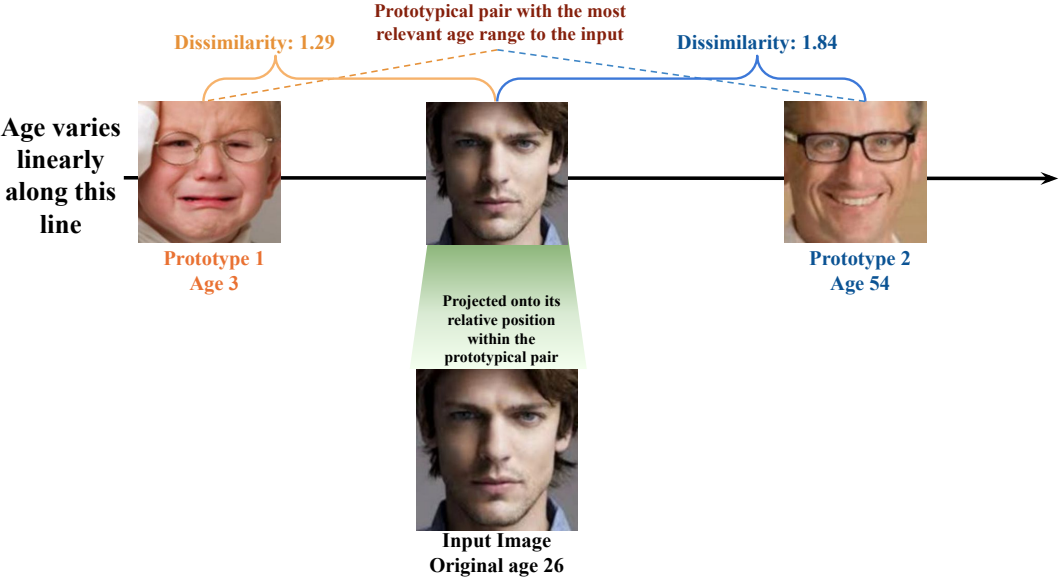
Reasoning with Prototypical pair:



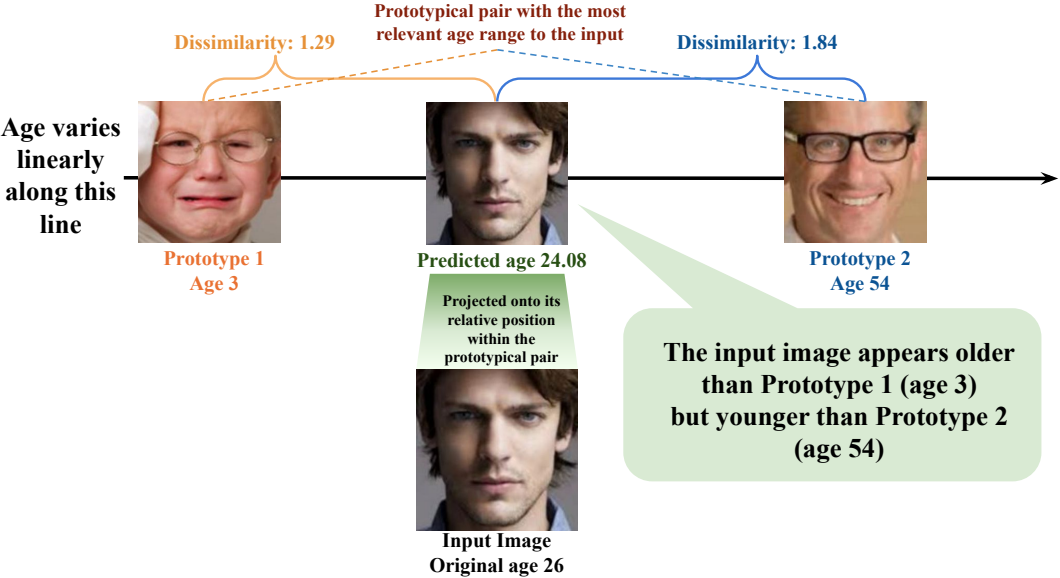
Reasoning with Prototypical pair:



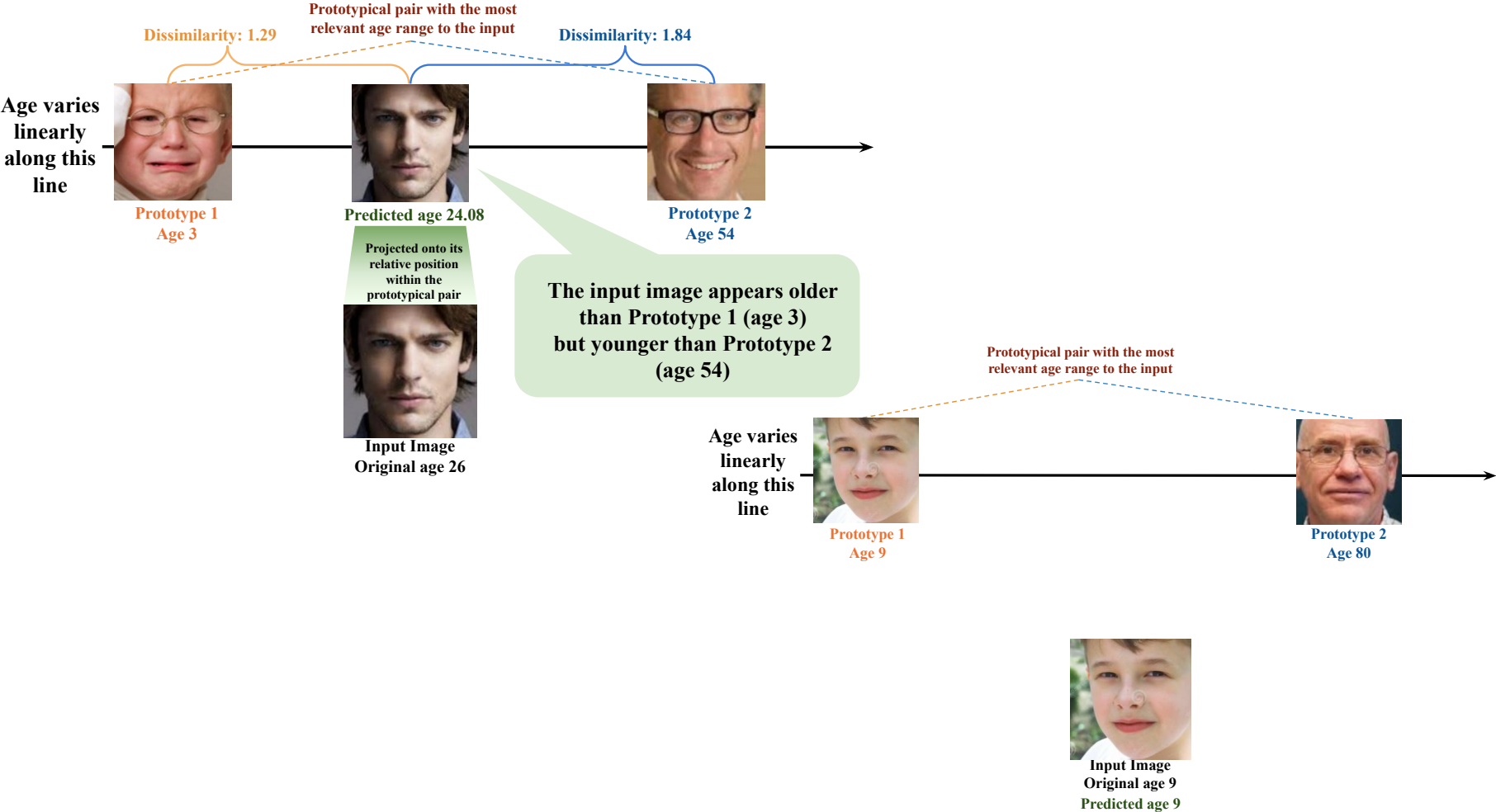
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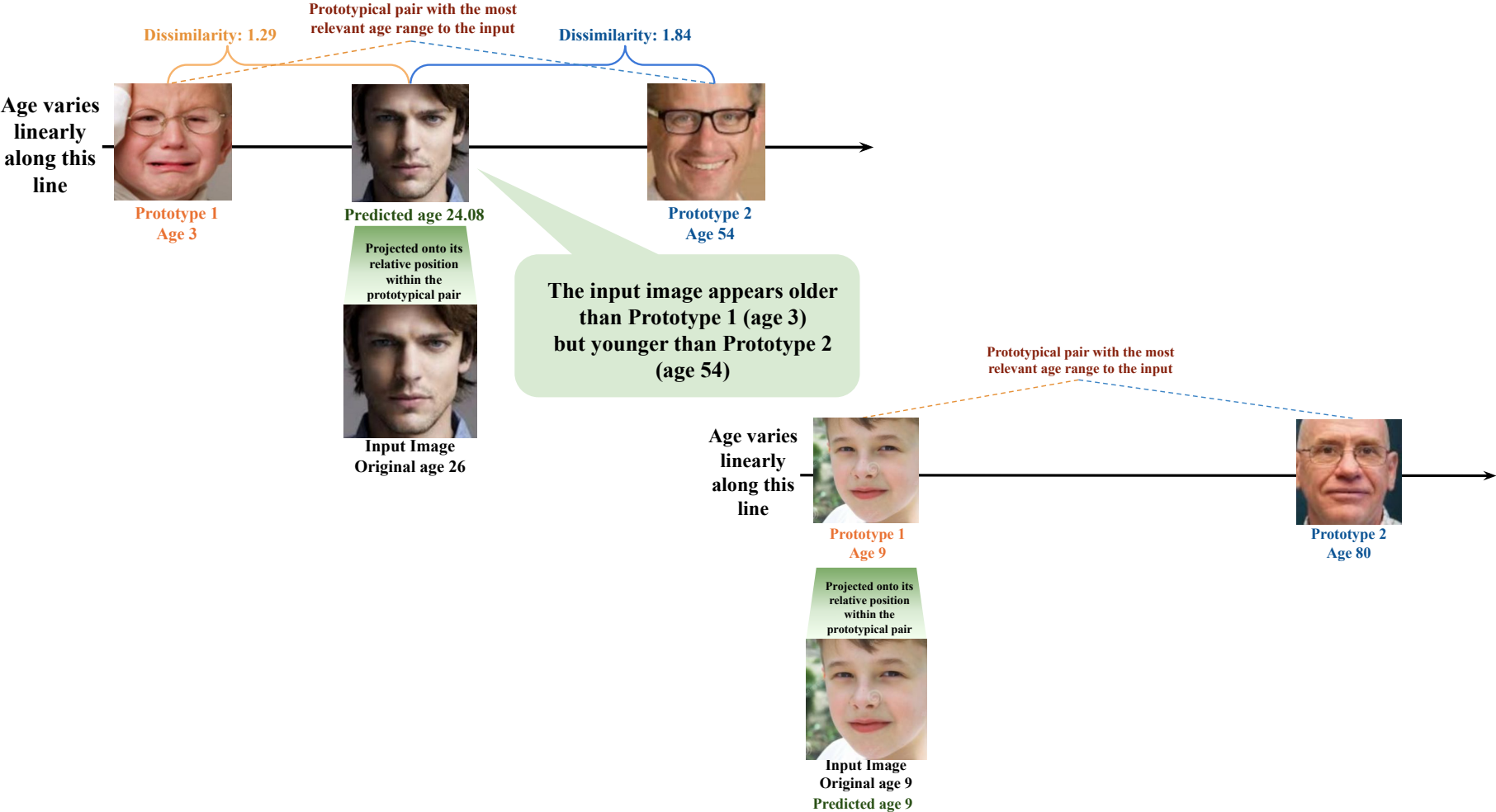
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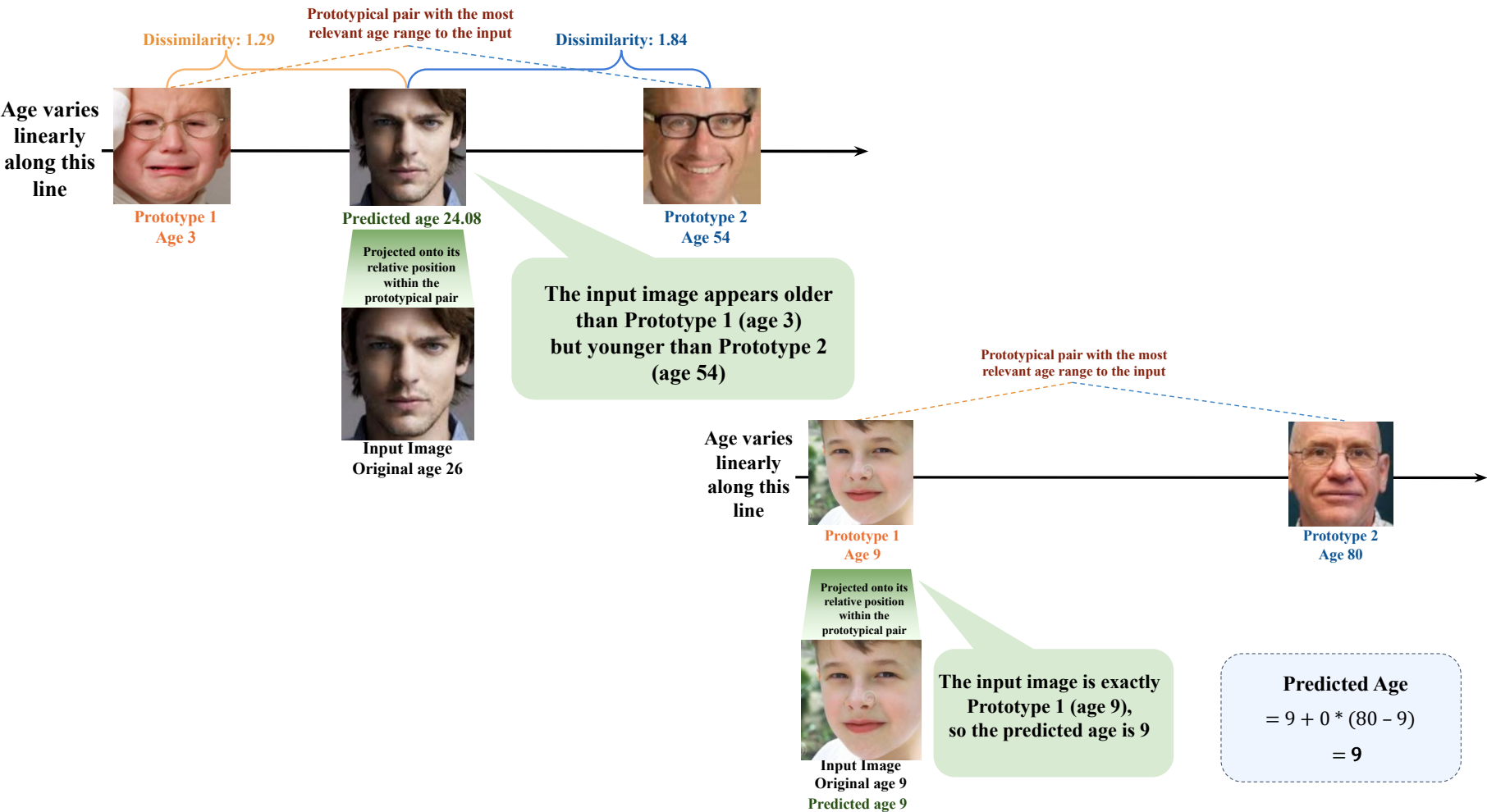
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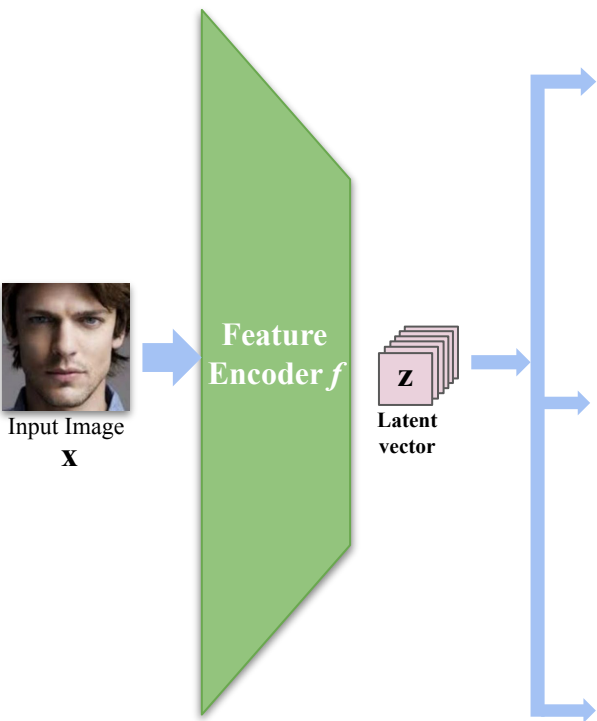


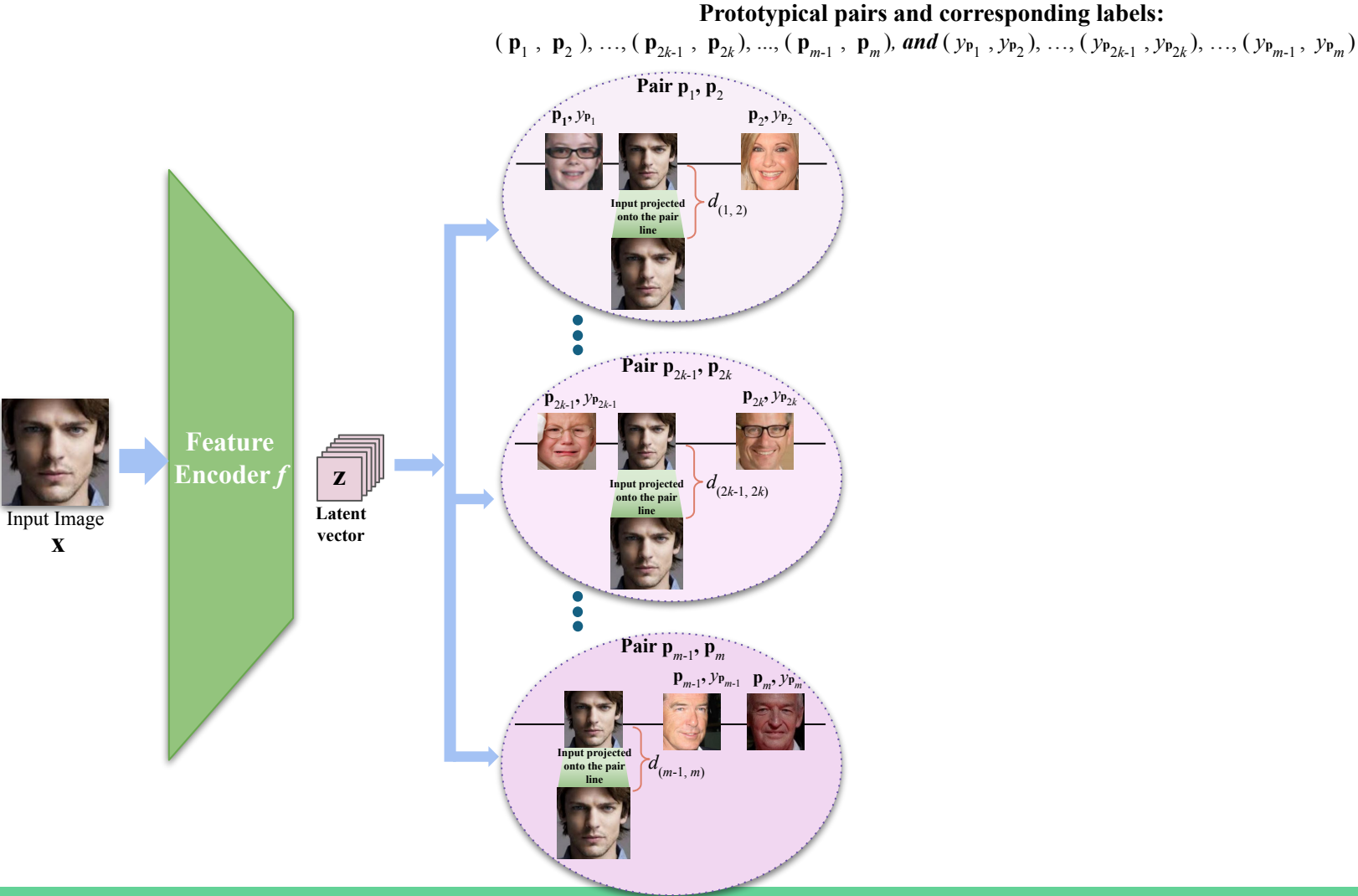
Reasoning with Prototypical pair:

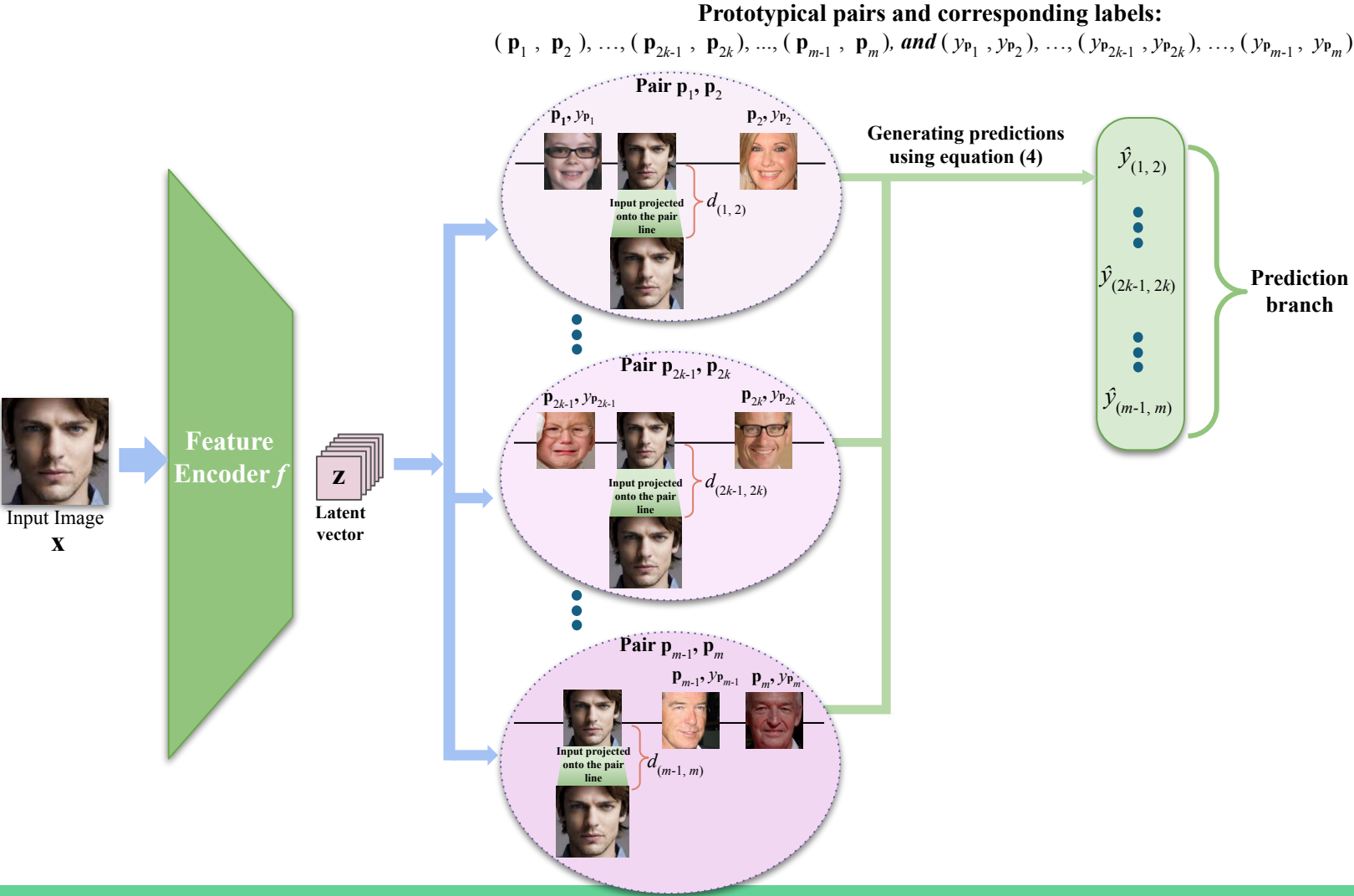


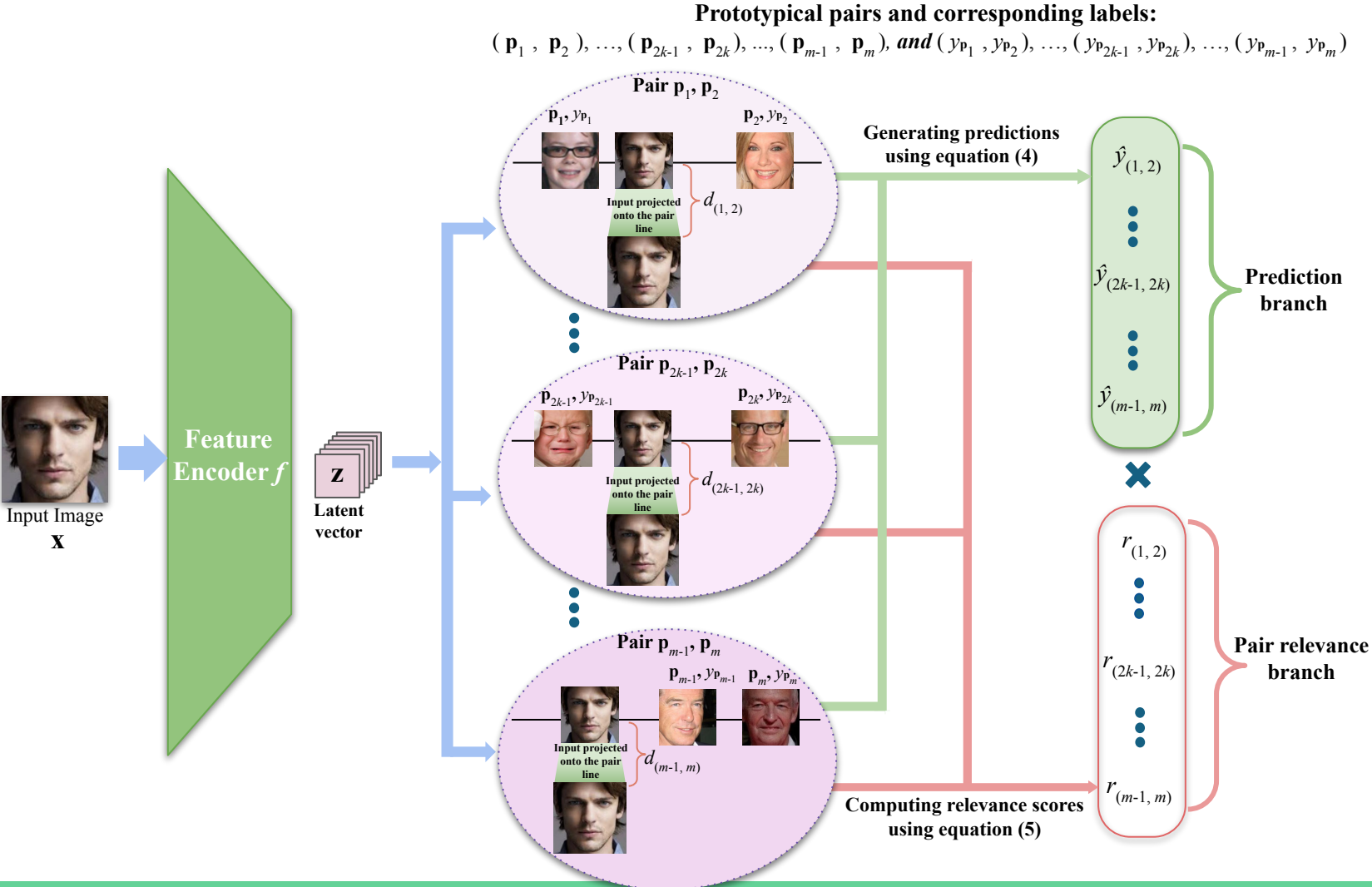
Reasoning with Prototypical pair:











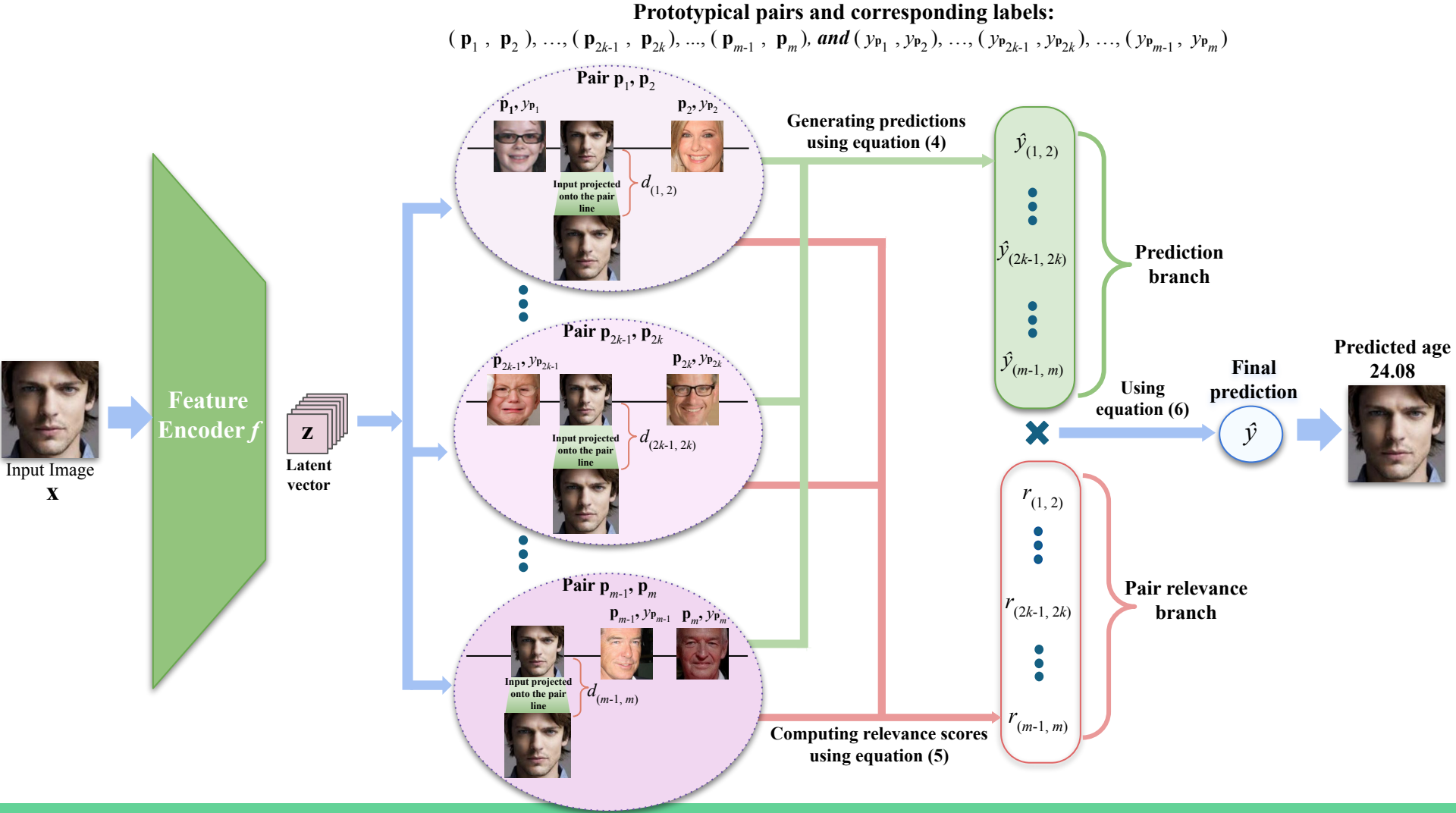


Table 1: Age prediction results. Comparison of ProtoPairNet with baseline black-box models (without prototypes) in terms of MAE and R^2 scores across different architectures.

Architecture	ResNet50		EfficientNet-B0		VGG19		ViT-Small (Patch 16)	
	MAE	R^2 Score	MAE	R^2 Score	MAE	R^2 Score	MAE	R^2 Score
Baseline	4.71 ± 0.09	0.86 ± 0.004	4.82 ± 0.08	0.86 ± 0.004	4.73 ± 0.07	0.86 ± 0.005	4.81 ± 0.06	0.86 ± 0.004
ProtoPairNet (Ours)	4.59 ± 0.01	0.87 ± 0.001	4.88 ± 0.03	0.86 ± 0.0006	4.57 ± 0.01	0.87 ± 0.001	4.63 ± 0.04	0.87 ± 0.001

Table 2: Comparison of ProtoPairNet with other prototype-based ResNet50 models for regression using MAE and R^2 scores.

Model	MAE	R^2 score
HPN	5.08 ± 0.03	0.84 ± 0.001
INSightR-Net (1×1)	14.01 ± 0.01	-0.03 ± 0.001
INSightR-Net (full)	14.81 ± 0.40	-0.08 ± 0.07
ExPeRT	17.36 ± 2.79	-0.37 ± 0.41
ProtoPairNet (Ours)	4.59 ± 0.01	0.87 ± 0.001

Table 3: Car Racing results. Comparison of different architectures in terms of rewards.

Architecture	Reward
k-Means[21]	-2.09 ± 0.94
PW-Net*[21]	-9.48 ± 2.50
PW-Net[21]	220.61 ± 0.70
ProtoPairNet	223.97 ± 0.75
PPO Black Box Agent	221.36 ± 0.96

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