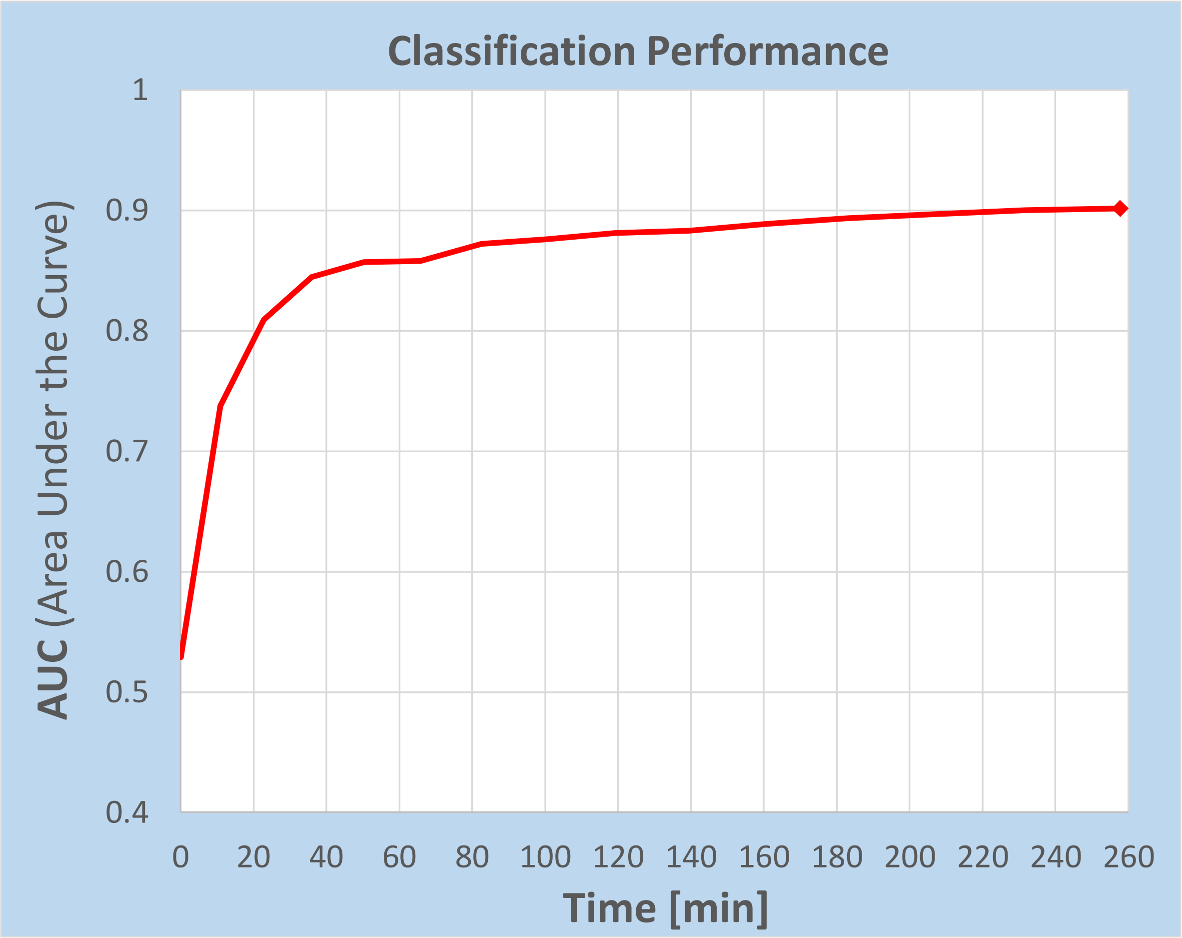
S9554 - Fast Training of Deep Neural Networks Using Brain-Generated Labels

Sergey Vaisman, VP R&D, InnerEye

“Without humans, artificial intelligence is still pretty stupid..” *(The Wall Street Journal)*

Image: The New York Times

AI Training Challenges



Brain In The Loop - Iterative AI Training Framework

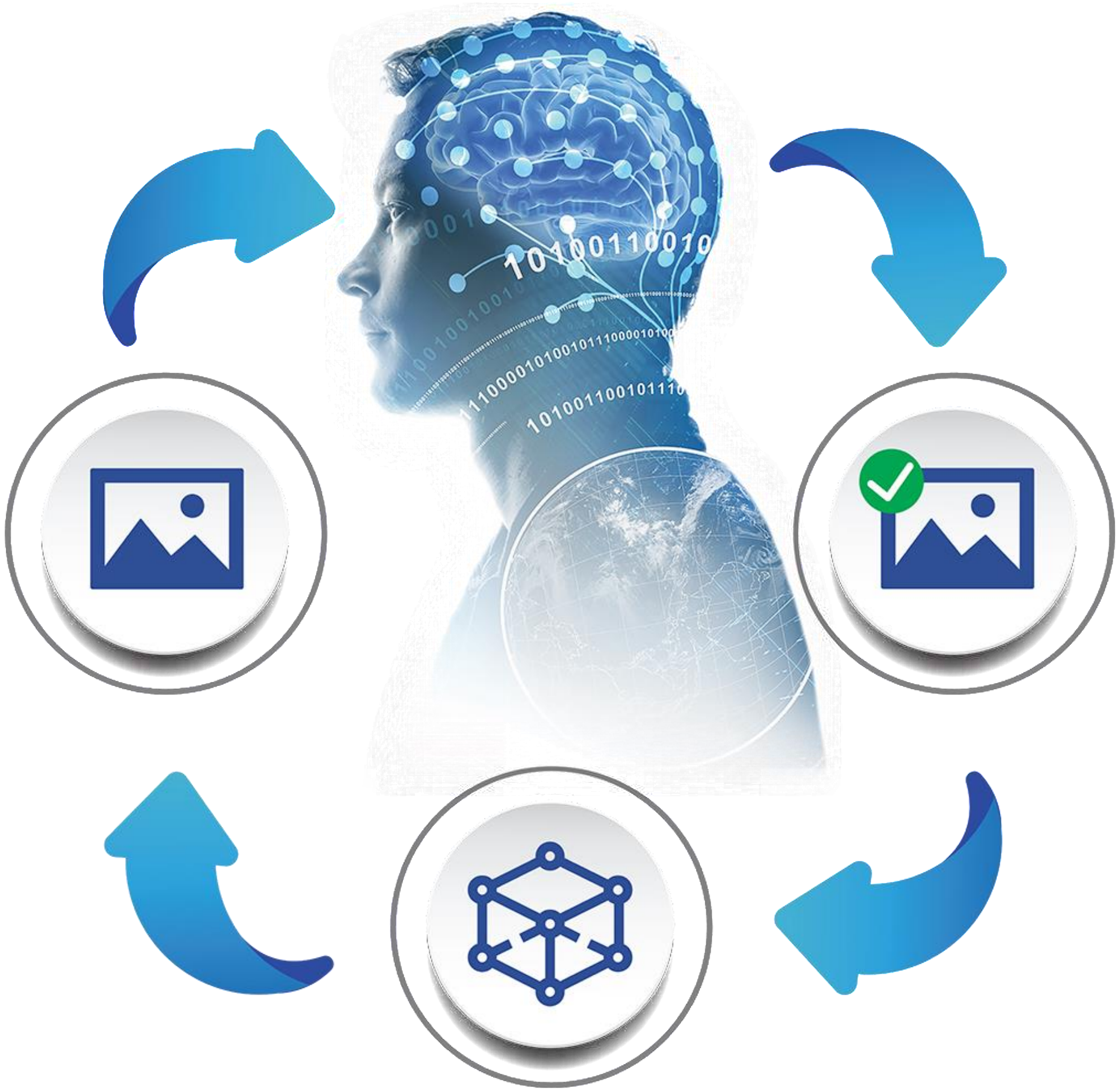
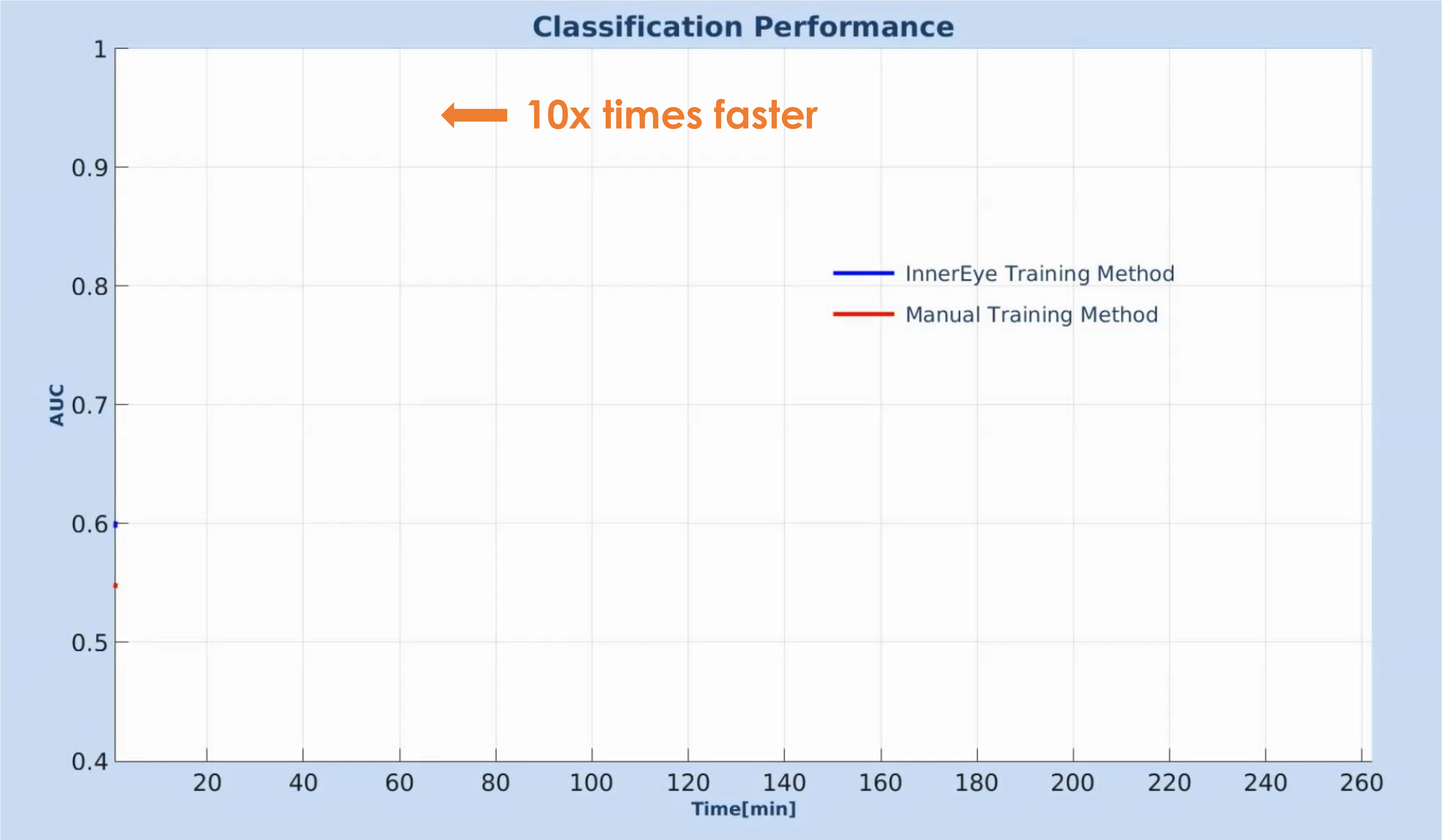


Image Classification Average Performance



Trained on NVIDIA GeForce GTX1080 ti GPU

InnerEye – The Company
Combining Human Intelligence with Artificial Intelligence

- Founded in 2014 - Technology spin-off from Israel's The Hebrew and Ben-Gurion Universities
- Offices in Herzliya, Israel and Tokyo, Japan
- Over $6M of funding provided so far
- Products: Visual content review, AI Training and Validation, Connected Human
- Management Team:

Uri Antman
CEO

Prof. Amir B. Geva
Founder and CTO

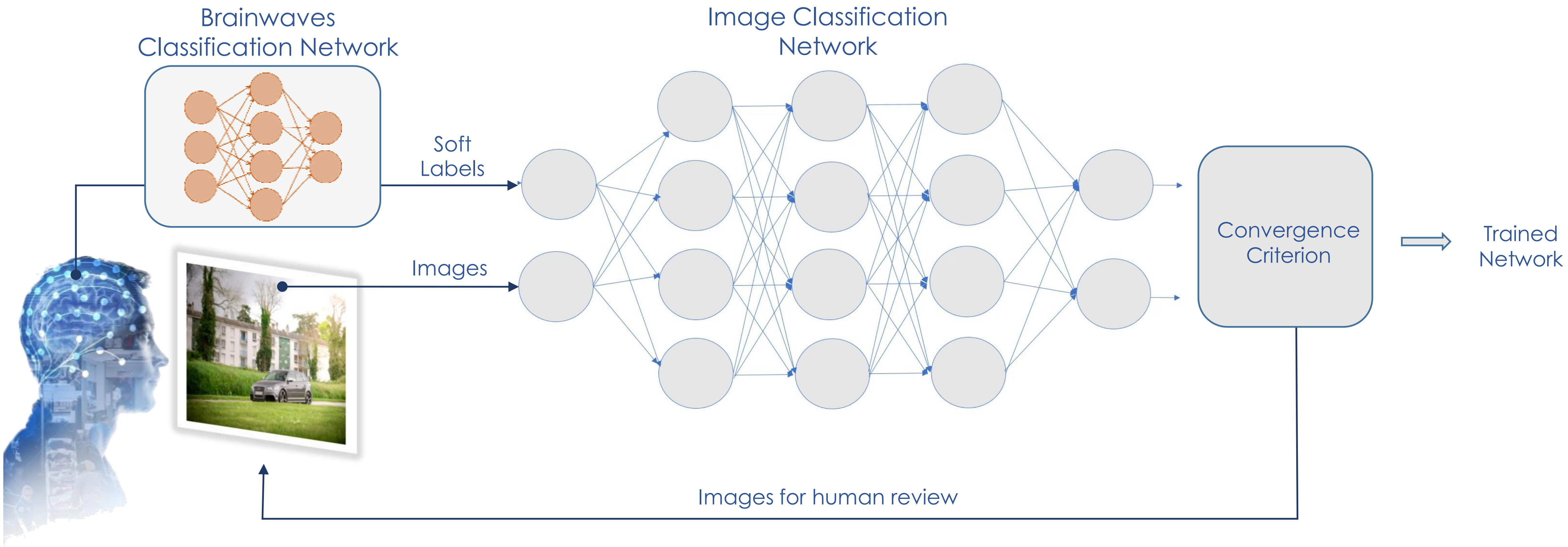
Prof. Leon Y. Deouell
Founder and CSO

Sergey Vaisman
VP R&D

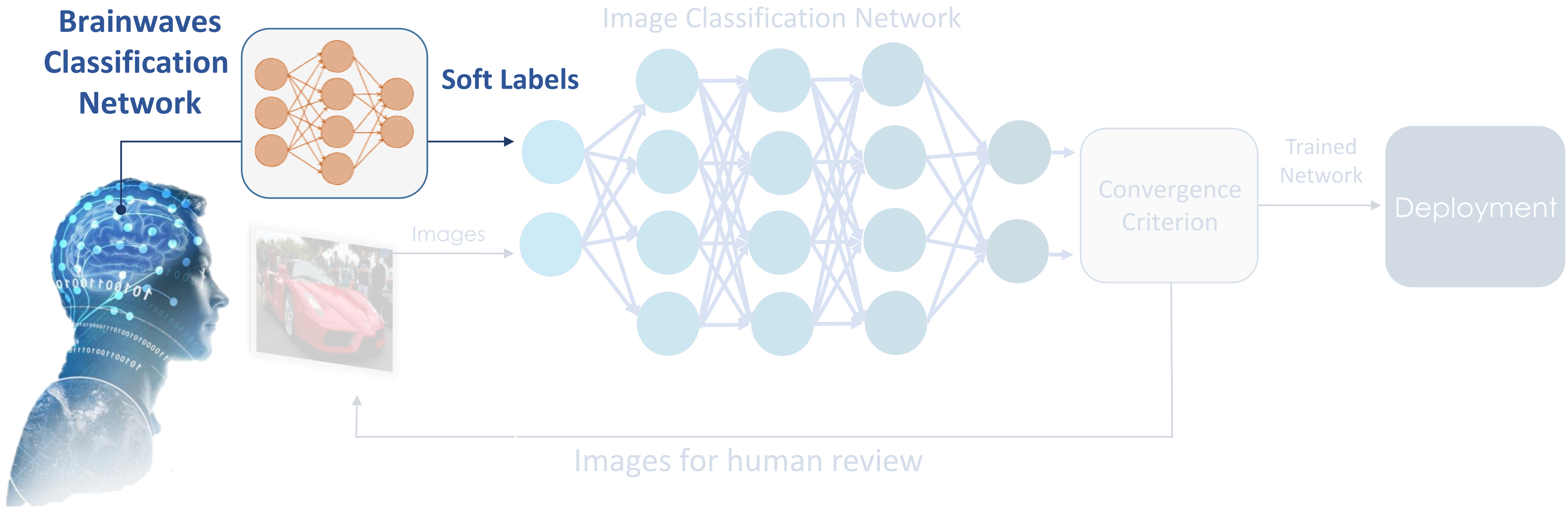
Agenda

- Iterative AI Training Framework
- Performance
- Use Cases

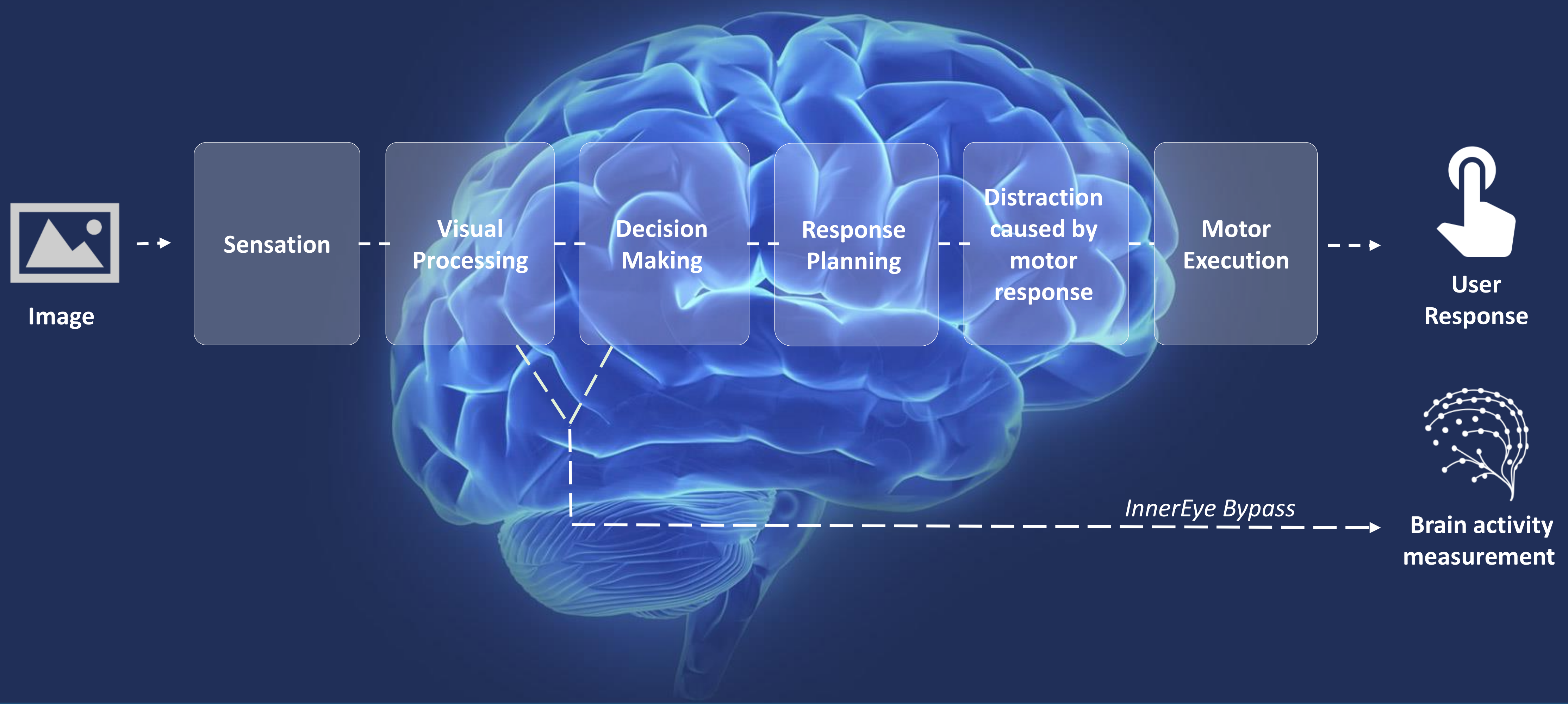
InnerEye AI Training Framework



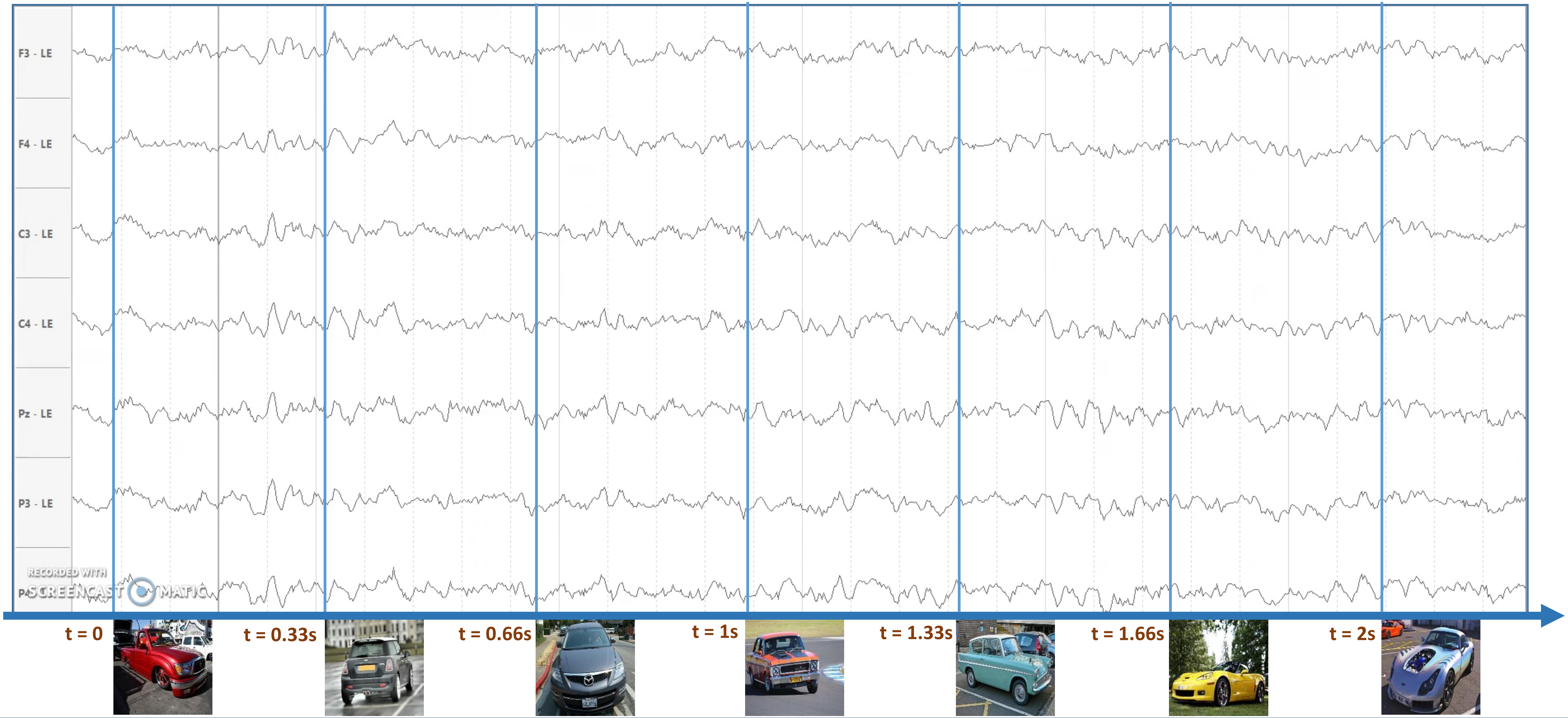
InnerEye AI Training Framework



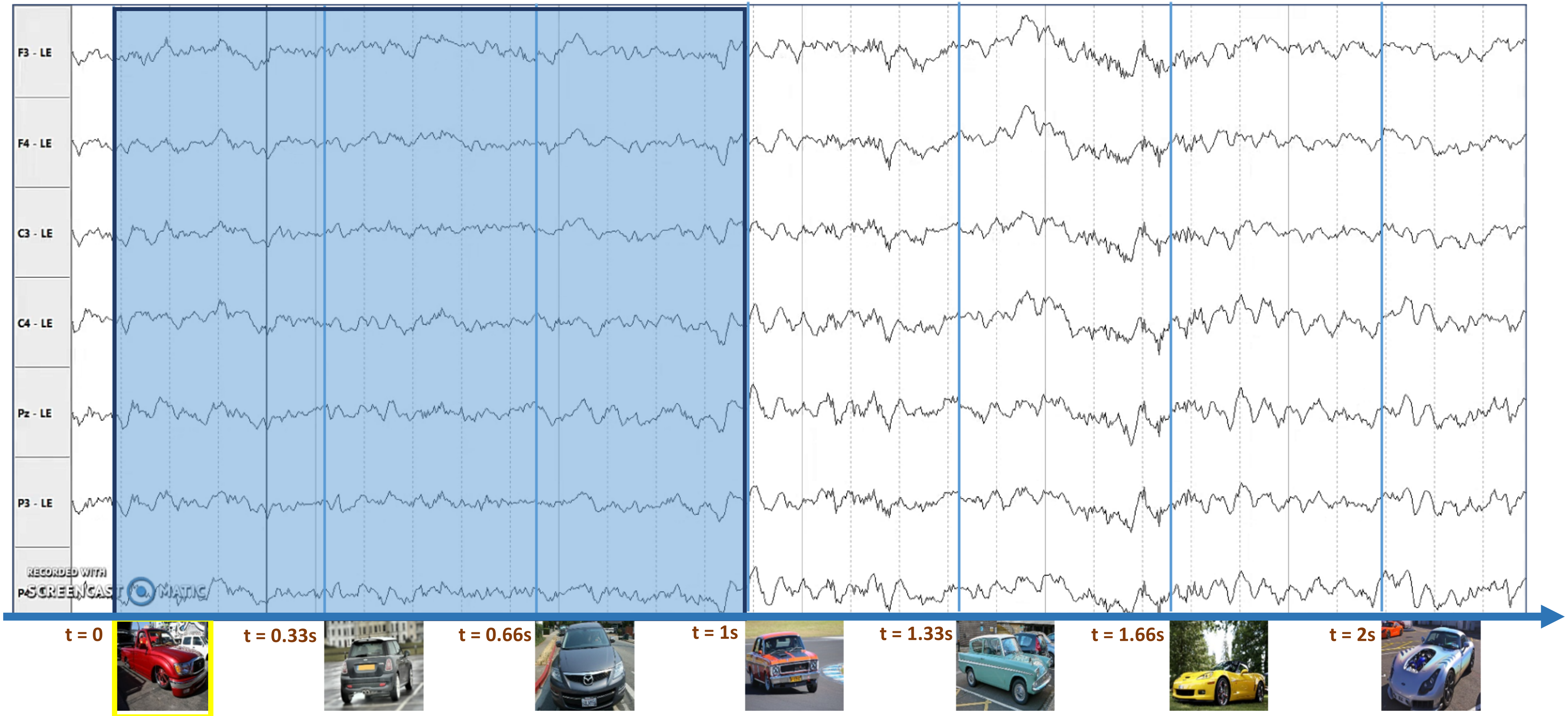
Tapping Into The Brain



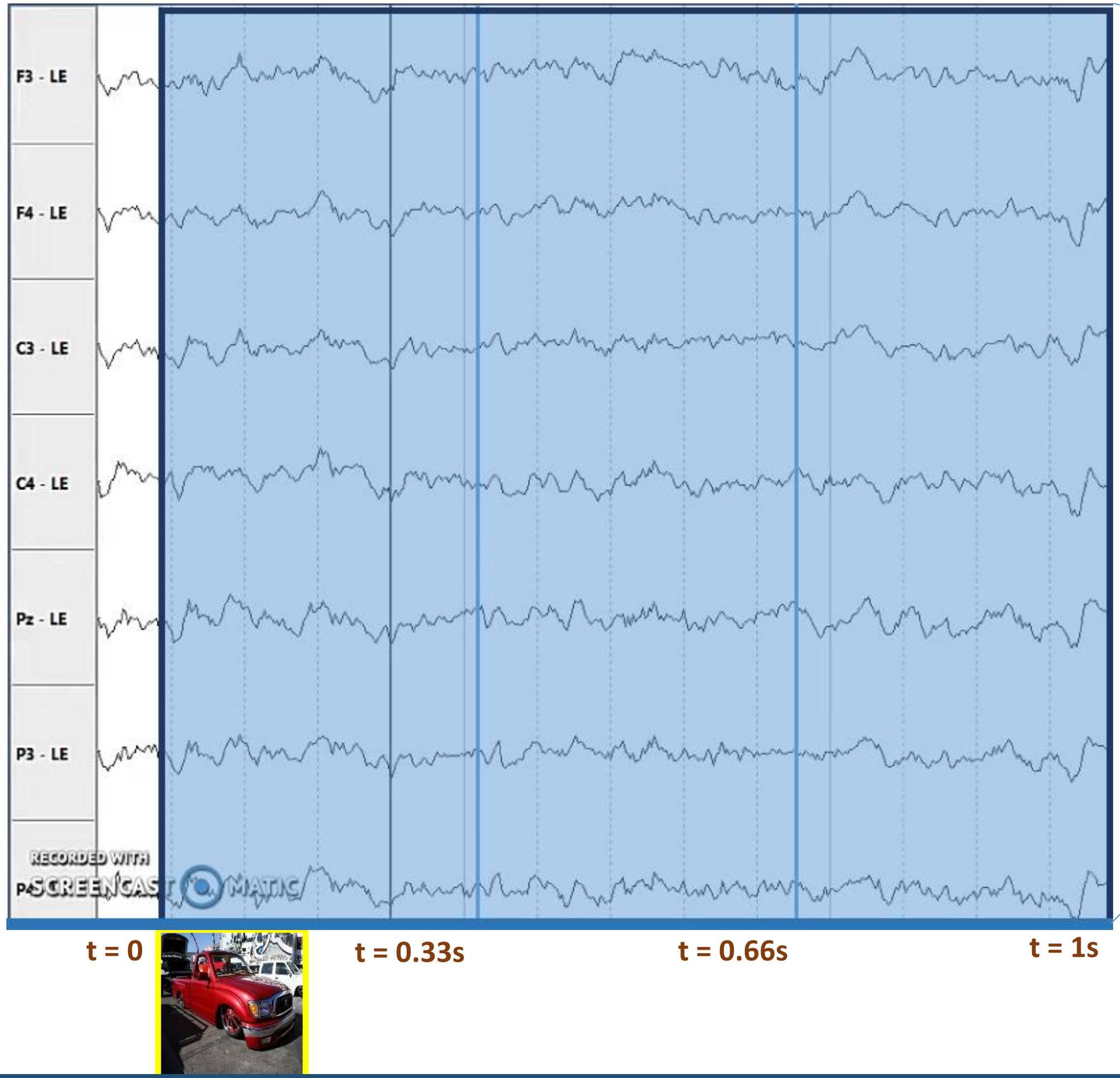
Brain Activity Measurement - EEG



Brain Activity Measurement - EEG

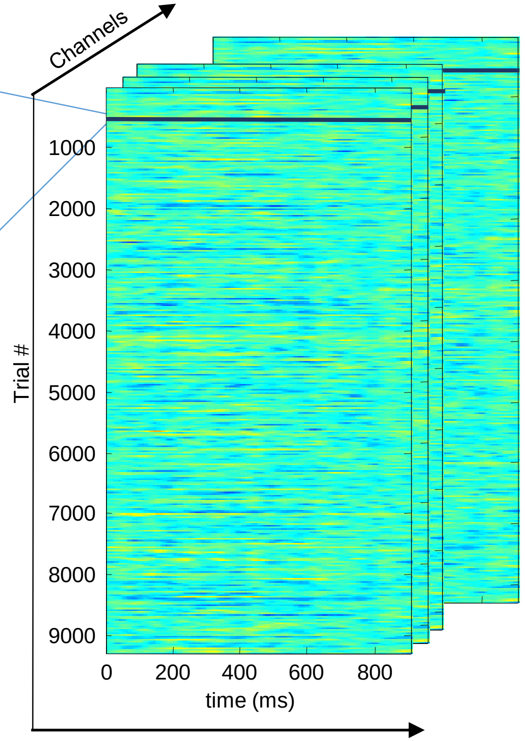


Single Trial Spatio-Temporal Activity

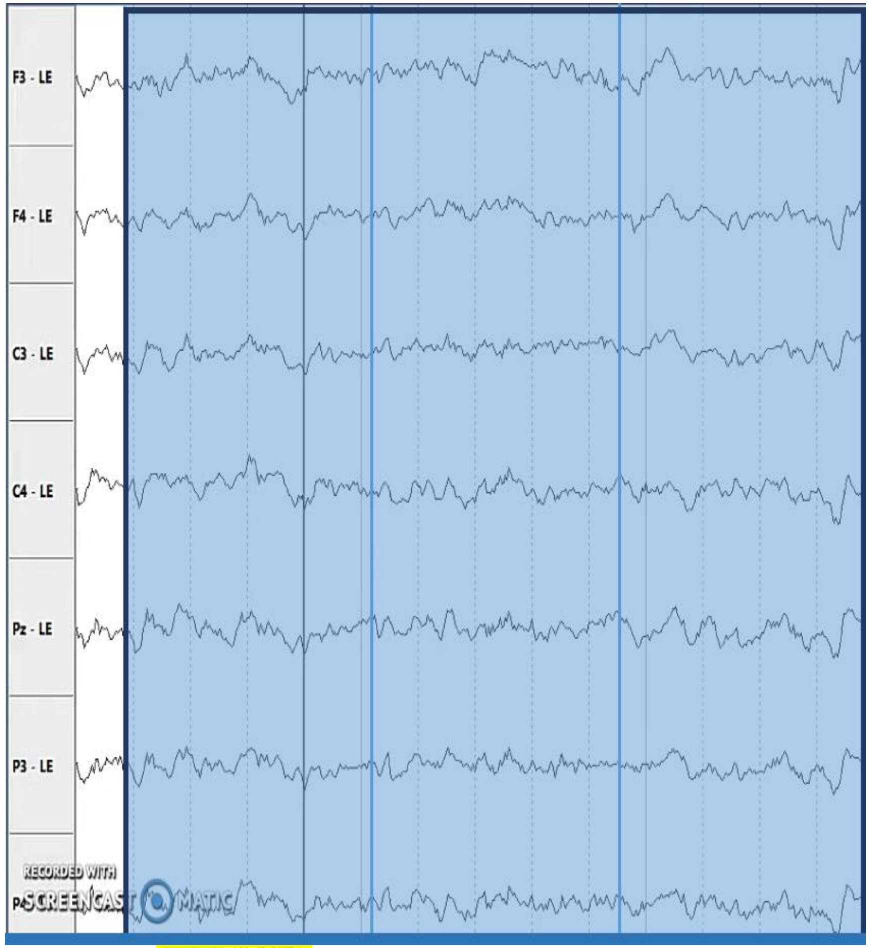


Single Trial
Spatio-Temporal Matrix

T Time samples
x ***D*** Channels

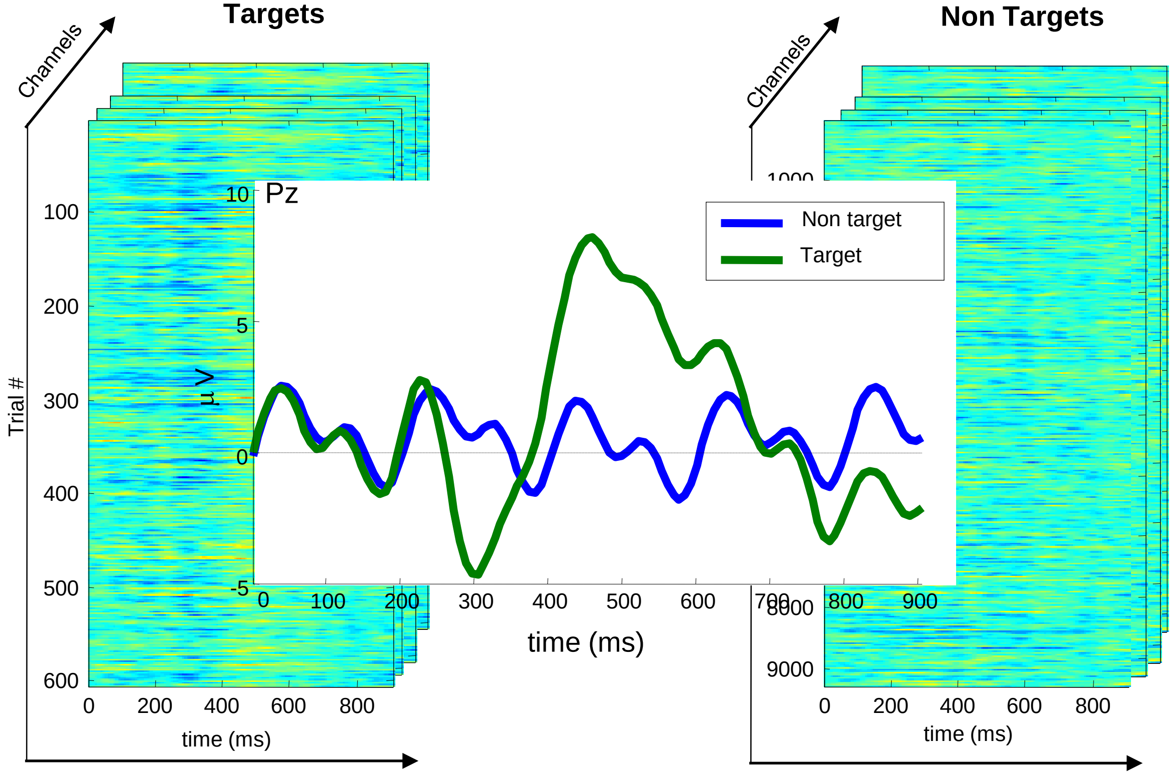


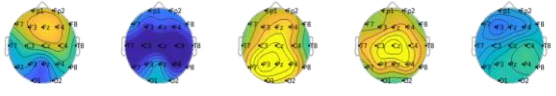
Single Trial Classification

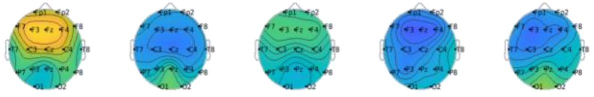


t = 0

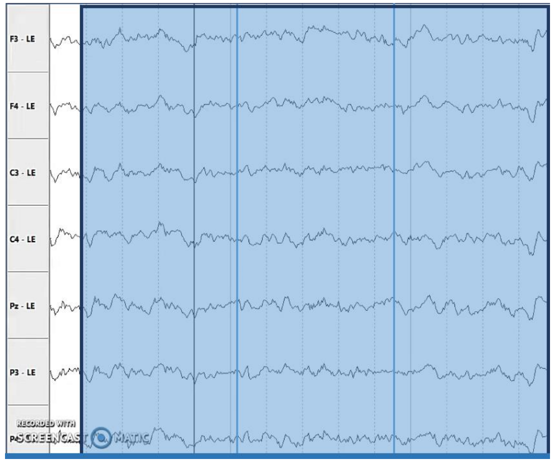
t = 1s





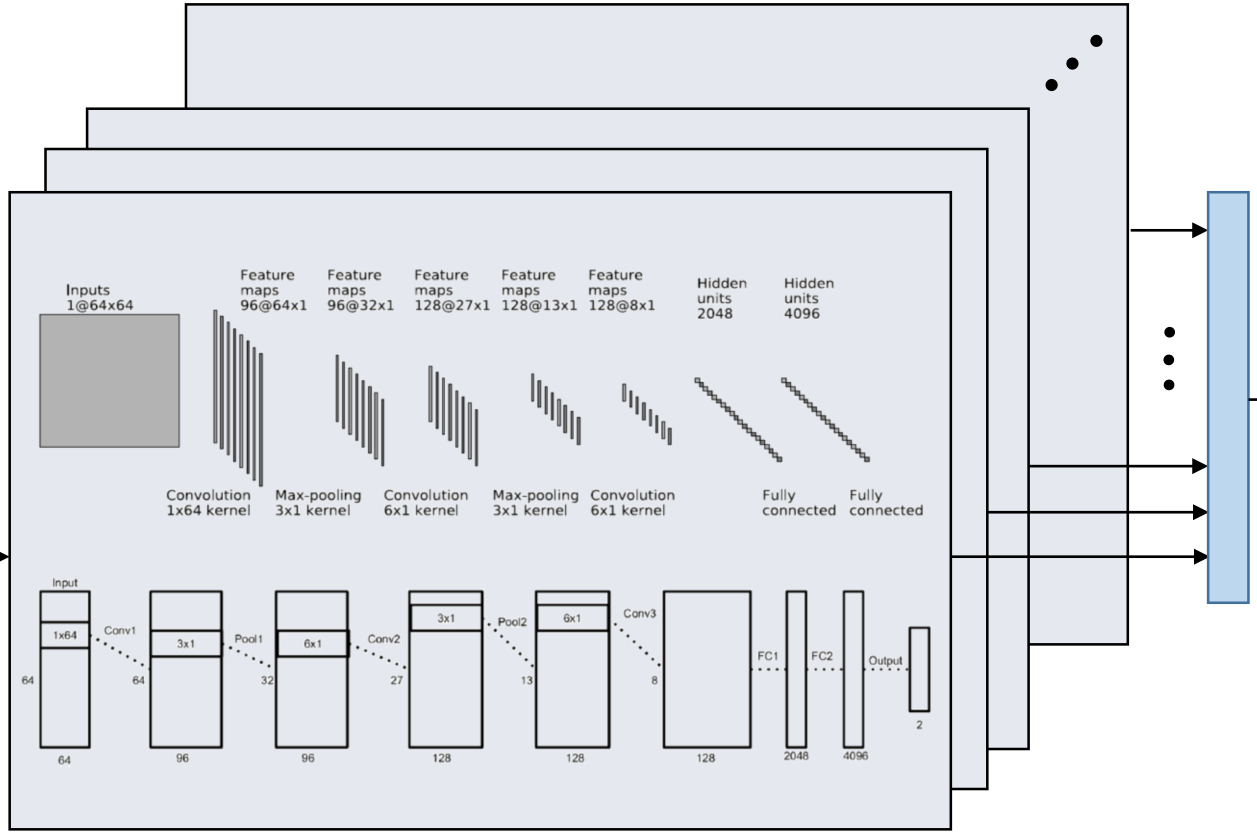


InnerEye Brainwaves Classification Network



INPUT:
Single Trial
Spatio-Temporal Matrix

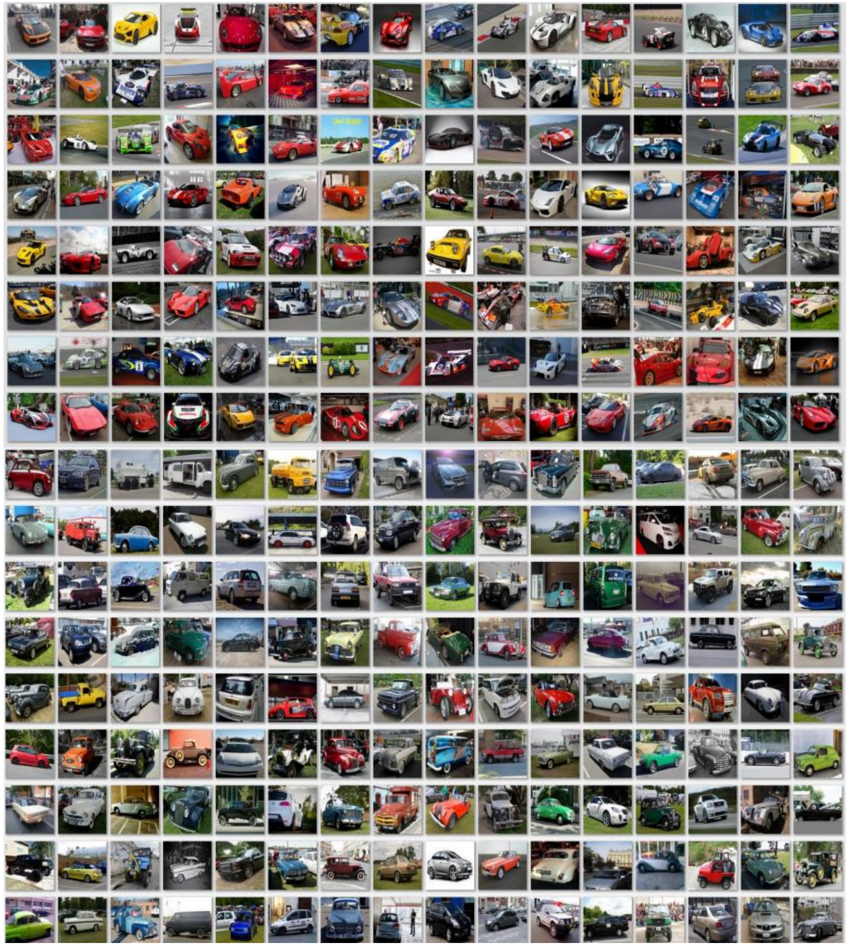
[***T*** Time samples
x ***D*** Channels]

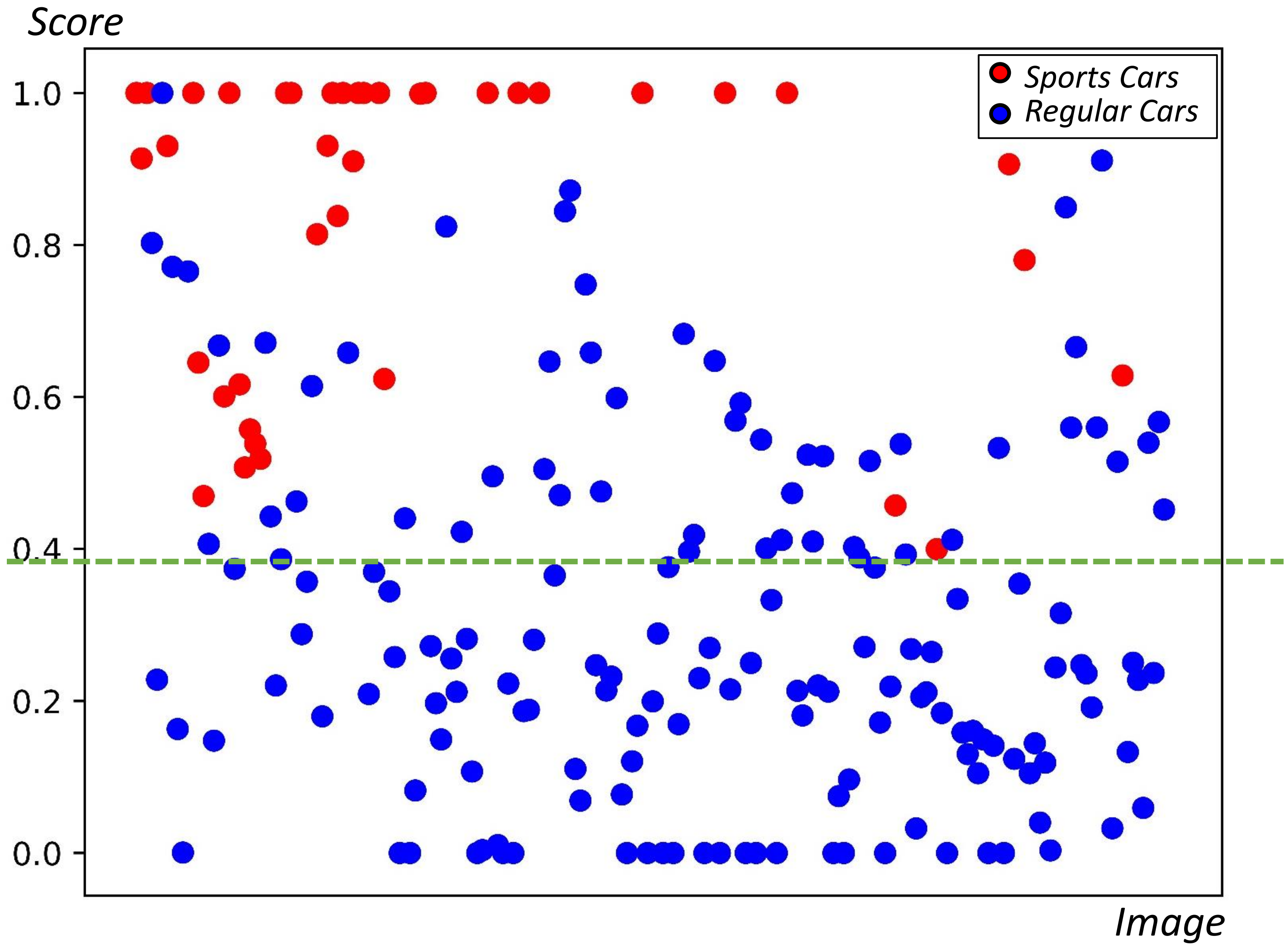


OUTPUT:
Trial Classification score

Deep Neural Network Ensemble

Brainwaves Classification Scores Distribution





Soft Labels Concept

- These images contain flowers but not all of them should contribute equally to the learning process
- Can we create more informative labels to address the diversity and improve classification accuracy?

Label: **FLOWER**

Label: **FLOWER**

Label: **FLOWER**

Image Source: Google Open Images Dataset

EEG Classification Scores Are Used to Generate Soft Labels

- Images that received high or low scores from the EEG classifier are given higher weight
- Images that received intermediate (inconclusive) scores from the EEG classifier are given lower weight

$$y_i = \begin{cases} 1, & c_i \geq THR \\ 0, & c_i < THR \end{cases}$$

$$w_i = \begin{cases} c_i, & y_i = 1 \\ 1 - c_i, & y_i = 0 \end{cases}$$

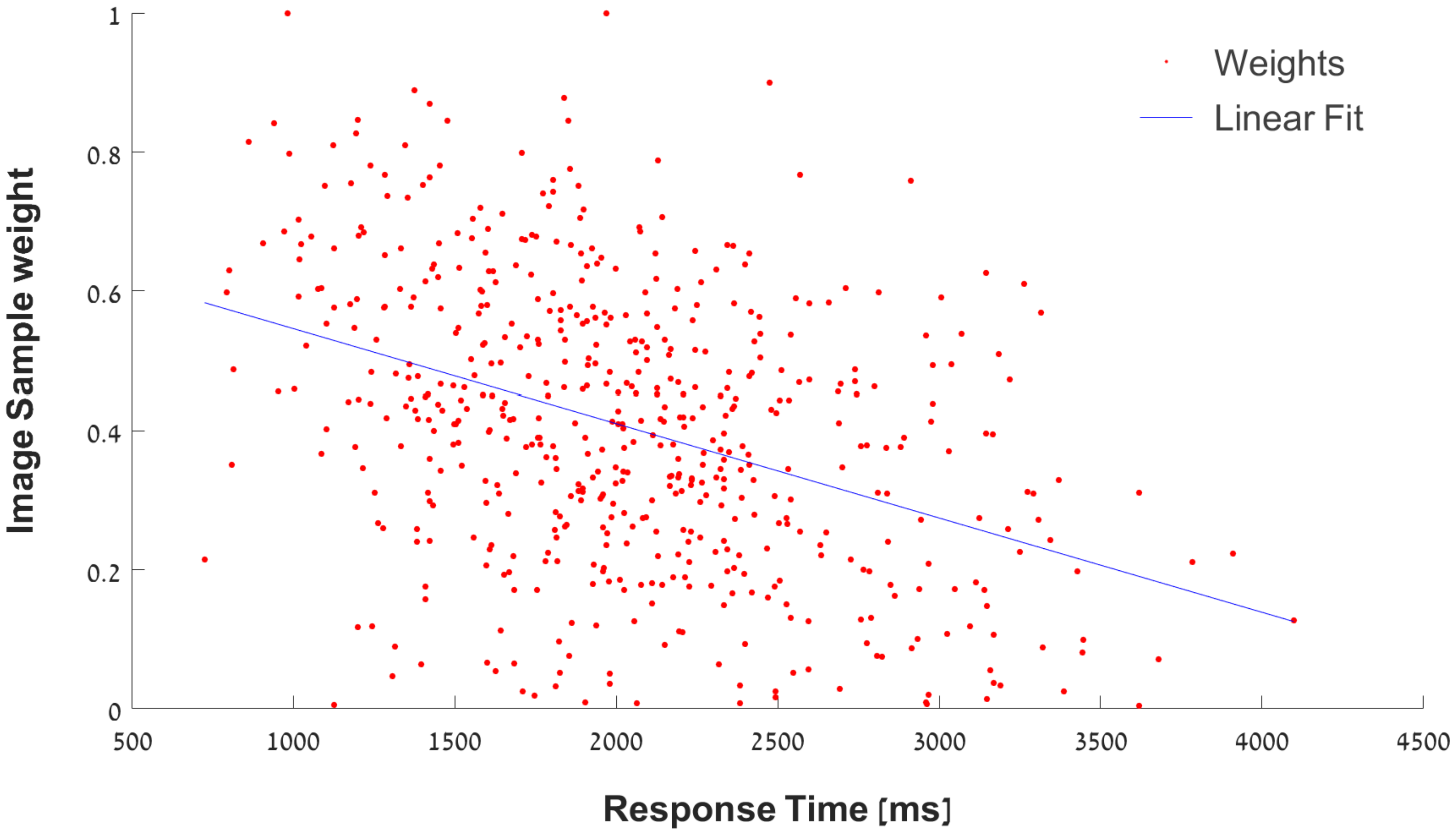
c_i = EEG Classification Score

y_i = Sample Label

w_i = Sample Weight (Soft Label)

THR = Classification Threshold

Soft Labels Are Correlated with Human Confidence Level



InnerEye AI Training Framework

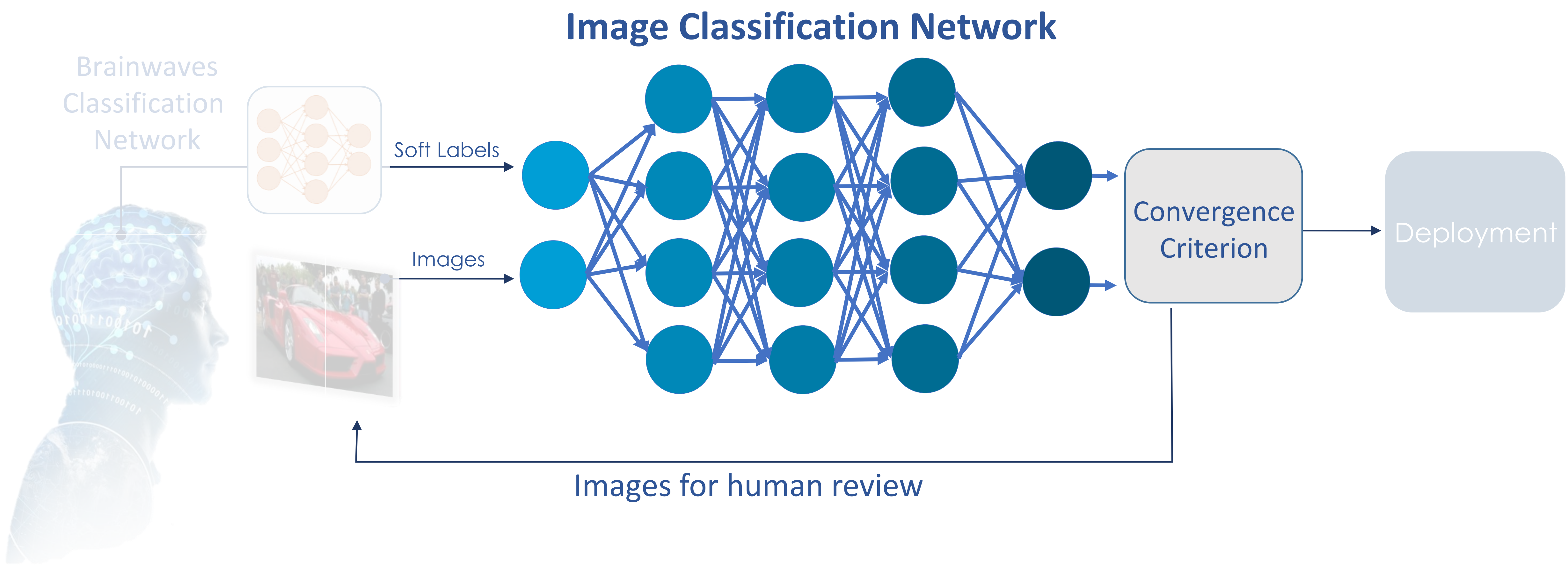
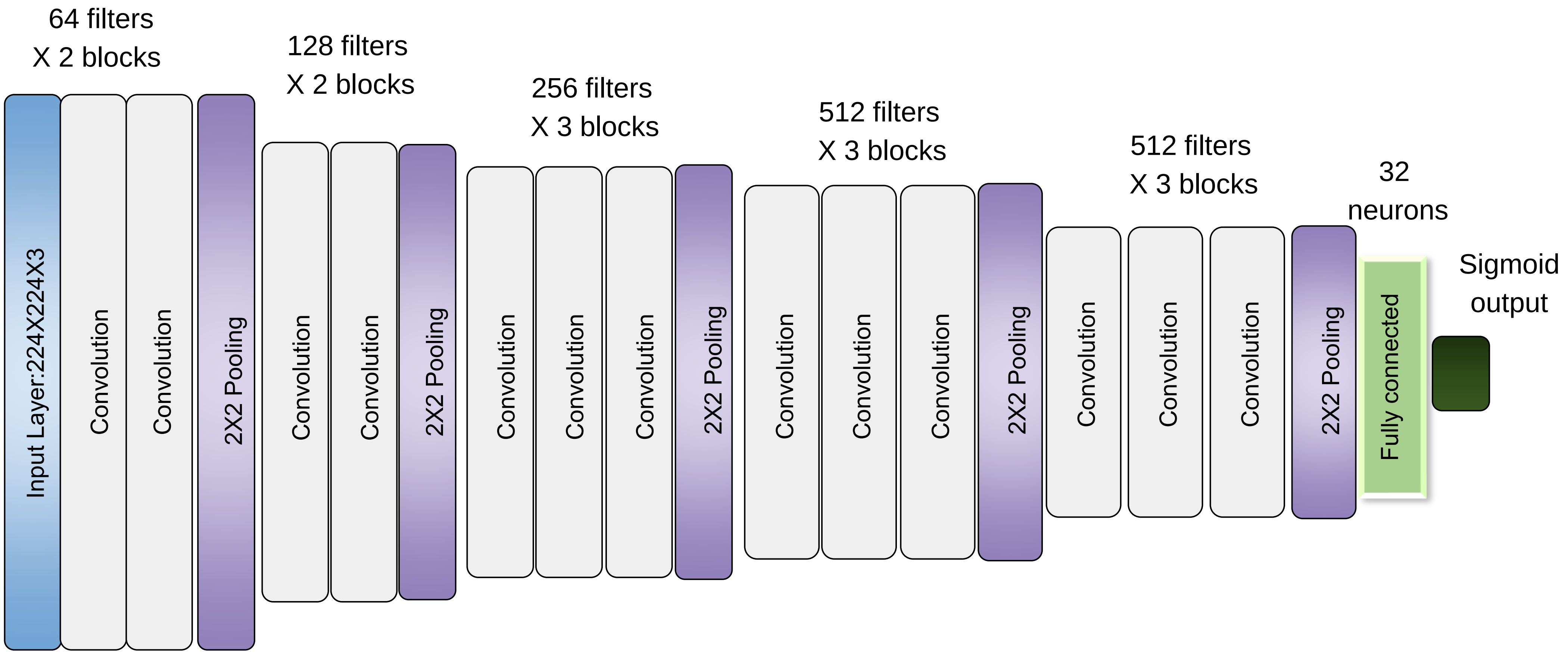


Image Classification Network

- In each iteration, image classification layers are trained using the new generated soft labels



Soft Labels Are Used As Sample Weights in Loss Function

- We add sample weights to the cross-entropy loss function:

$$L(x_i) = -\boldsymbol{w_i}(y_i log(p_i) + (1 - y_i) log(1 - p_i))$$

$L(x_i)$ = Cross Entropy Loss Function

x_i = Sample

y_i = Sample Label

w_i = Sample Weight (Soft Label)

p_i = Sample Prediction

Convergence and Active Learning Iterations

- The learning algorithm selects new samples to learn from in the next iteration based on Confidence criterion:

$$C_i = \max_j P(y_i = j | x_i)$$

C_i = Confidence for Sample i

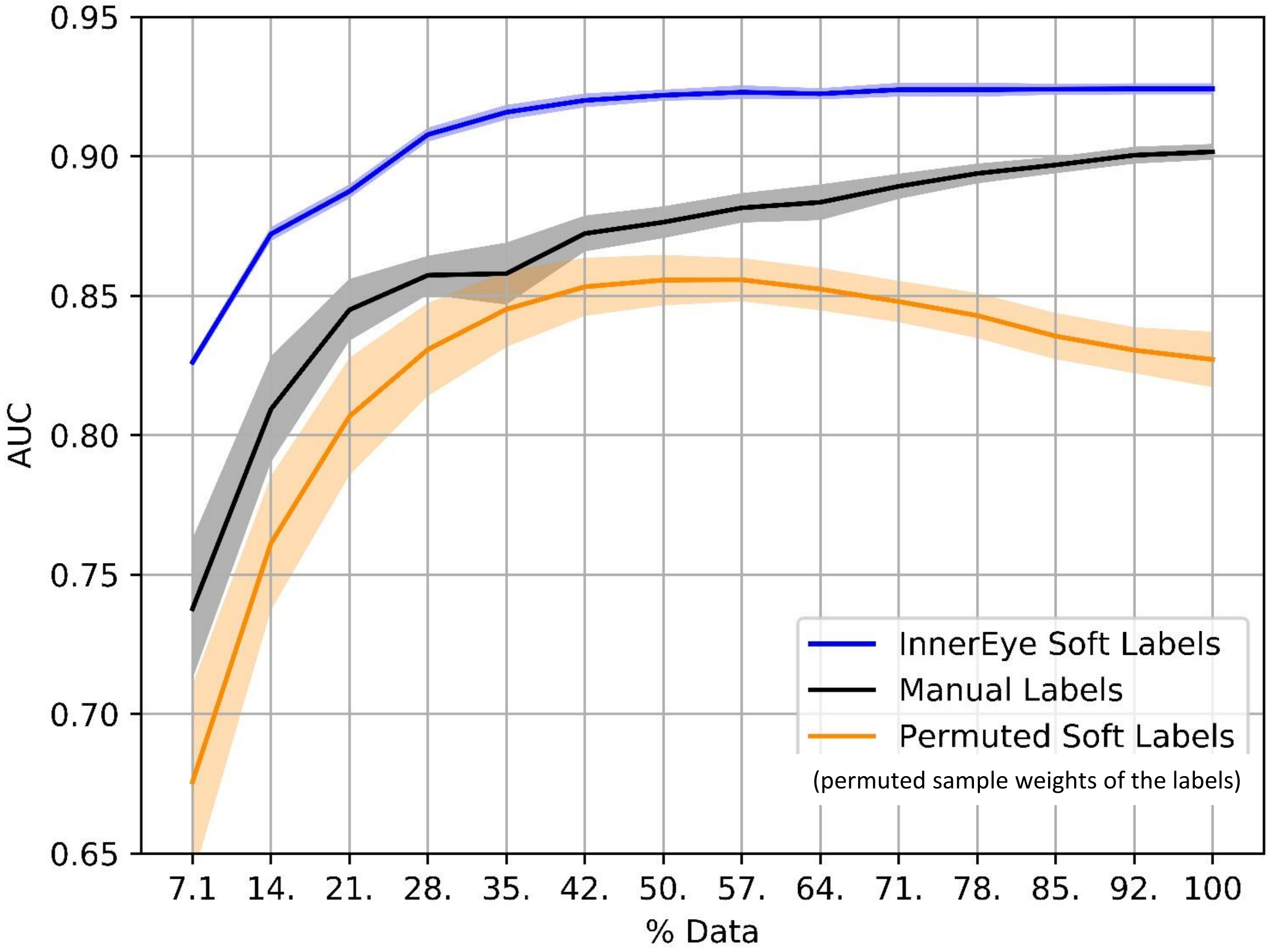
j = Class index

y_i = Predicted Sample label

x_i = Sample i

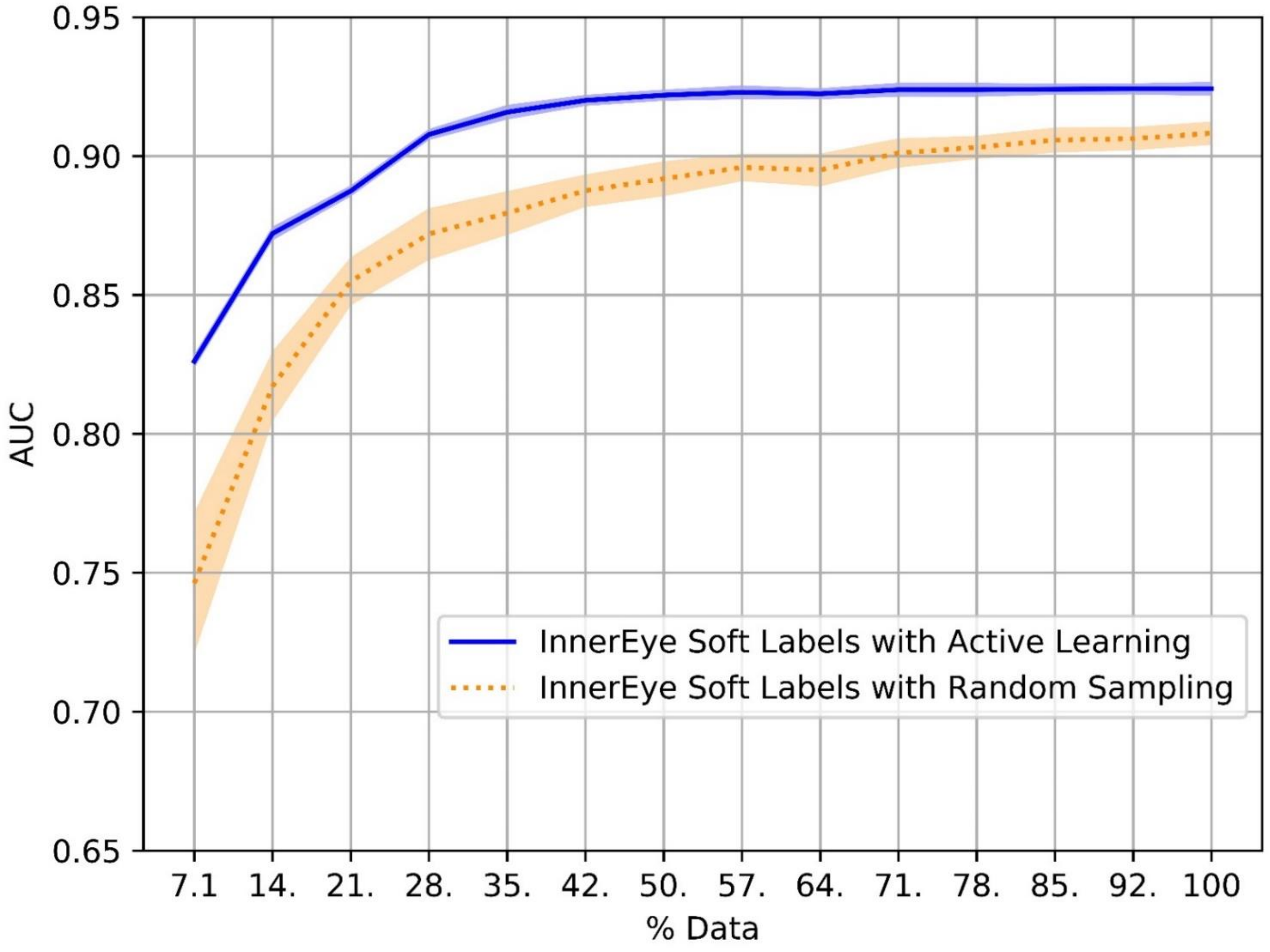
- Only the least confident samples (C_i < *THR)* will be sent for human review
- Also used as Convergence Condition

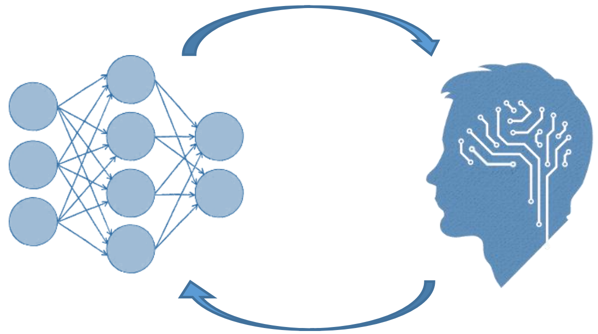
Soft Labels Improve Neural Network Performance



(*) AUC shown after the first iteration

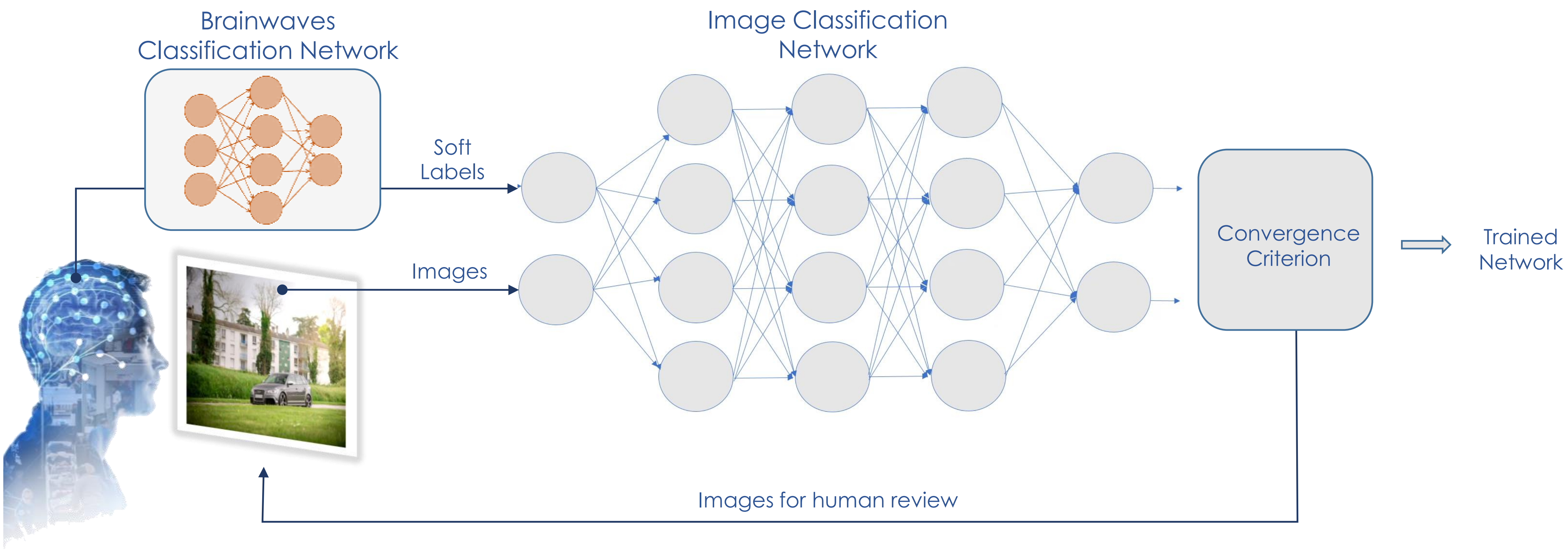
Active Learning Combined With Soft Labels Improves Neural Network Performance





(*) AUC shown after the first iteration

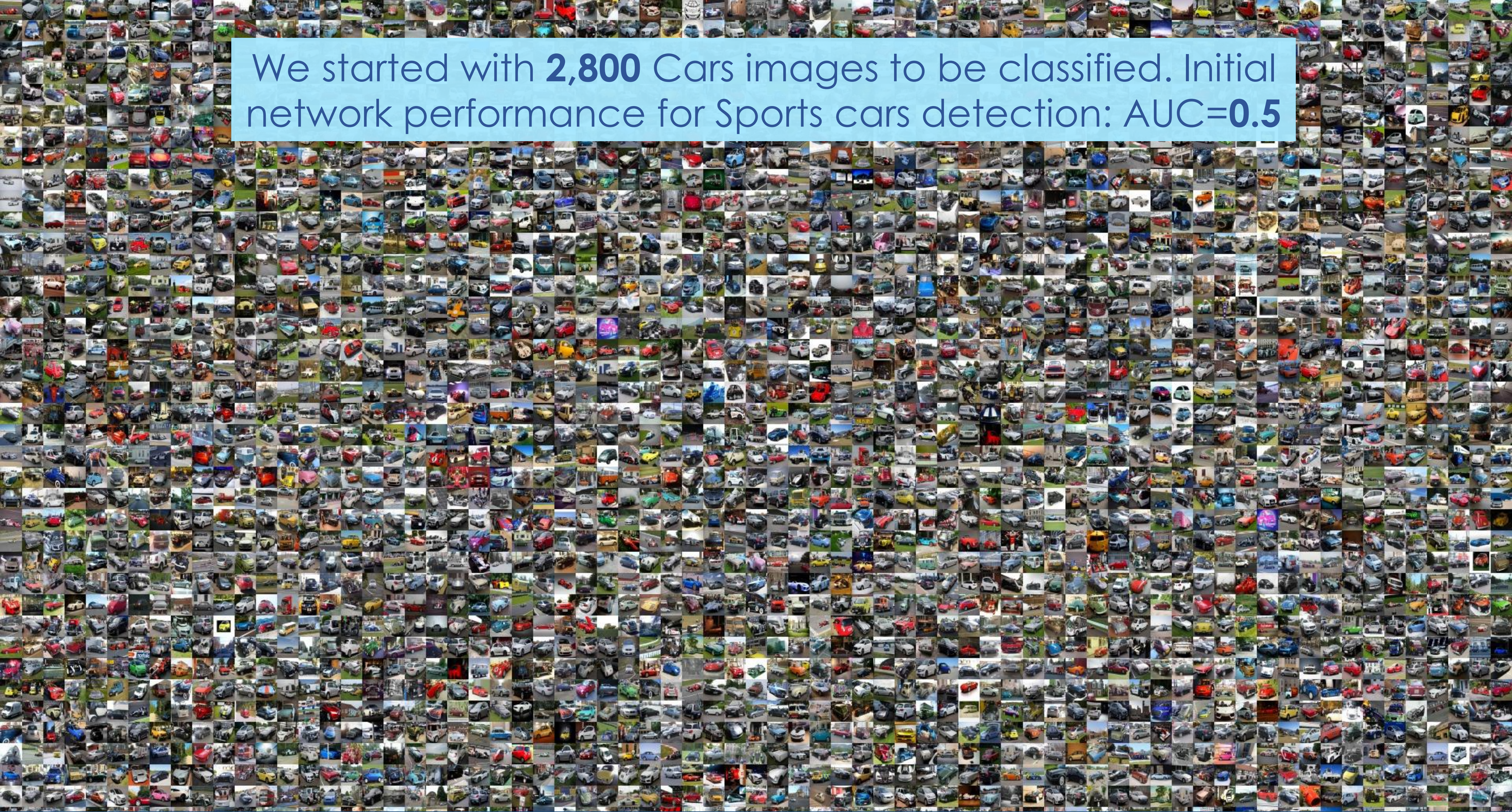
InnerEye AI Training Framework



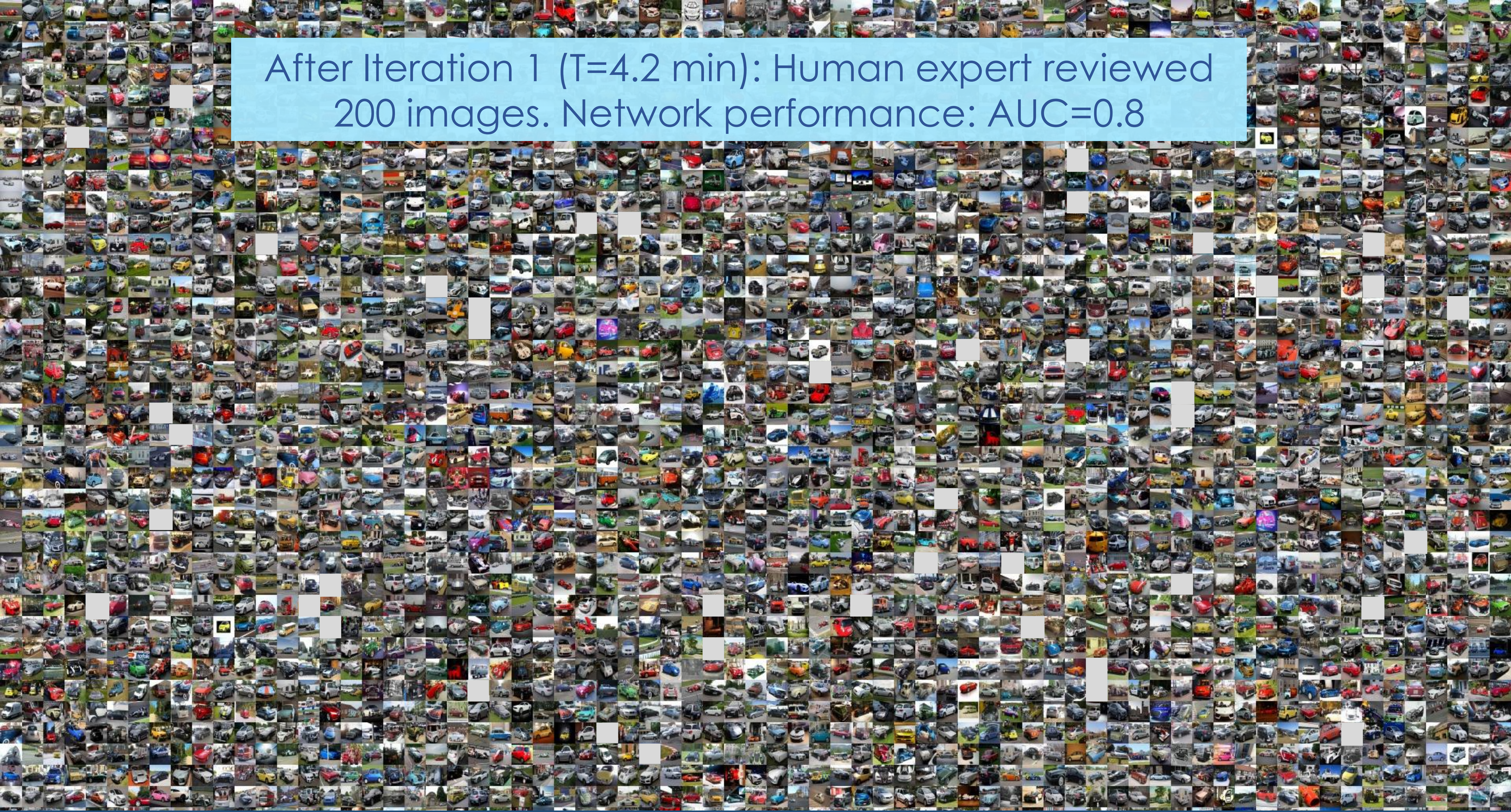
Agenda

- Iterative AI Training Framework
- Performance
- Use Cases

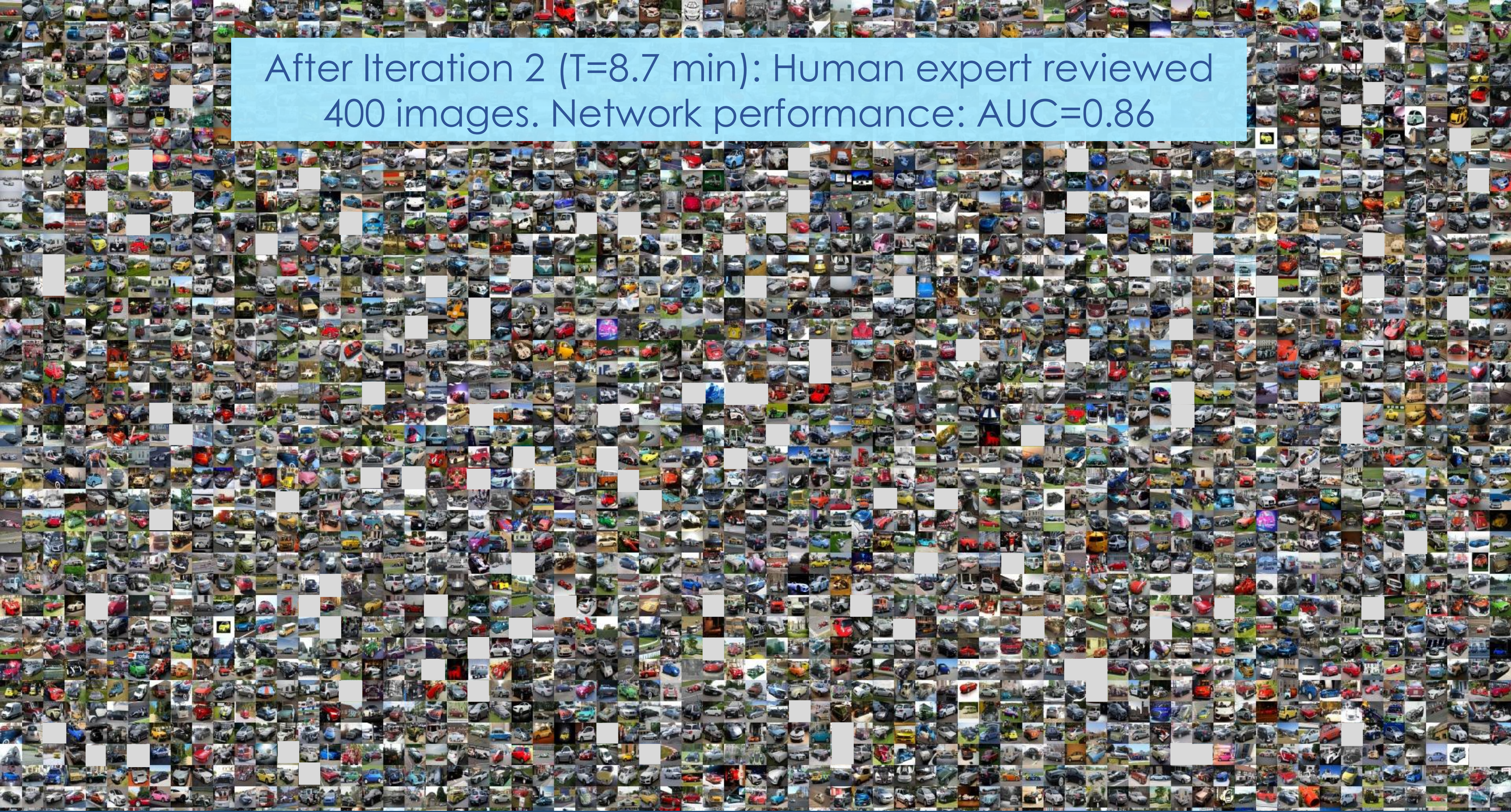
We started with **2,800** Cars images to be classified. Initial network performance for Sports cars detection: AUC=**0.5**



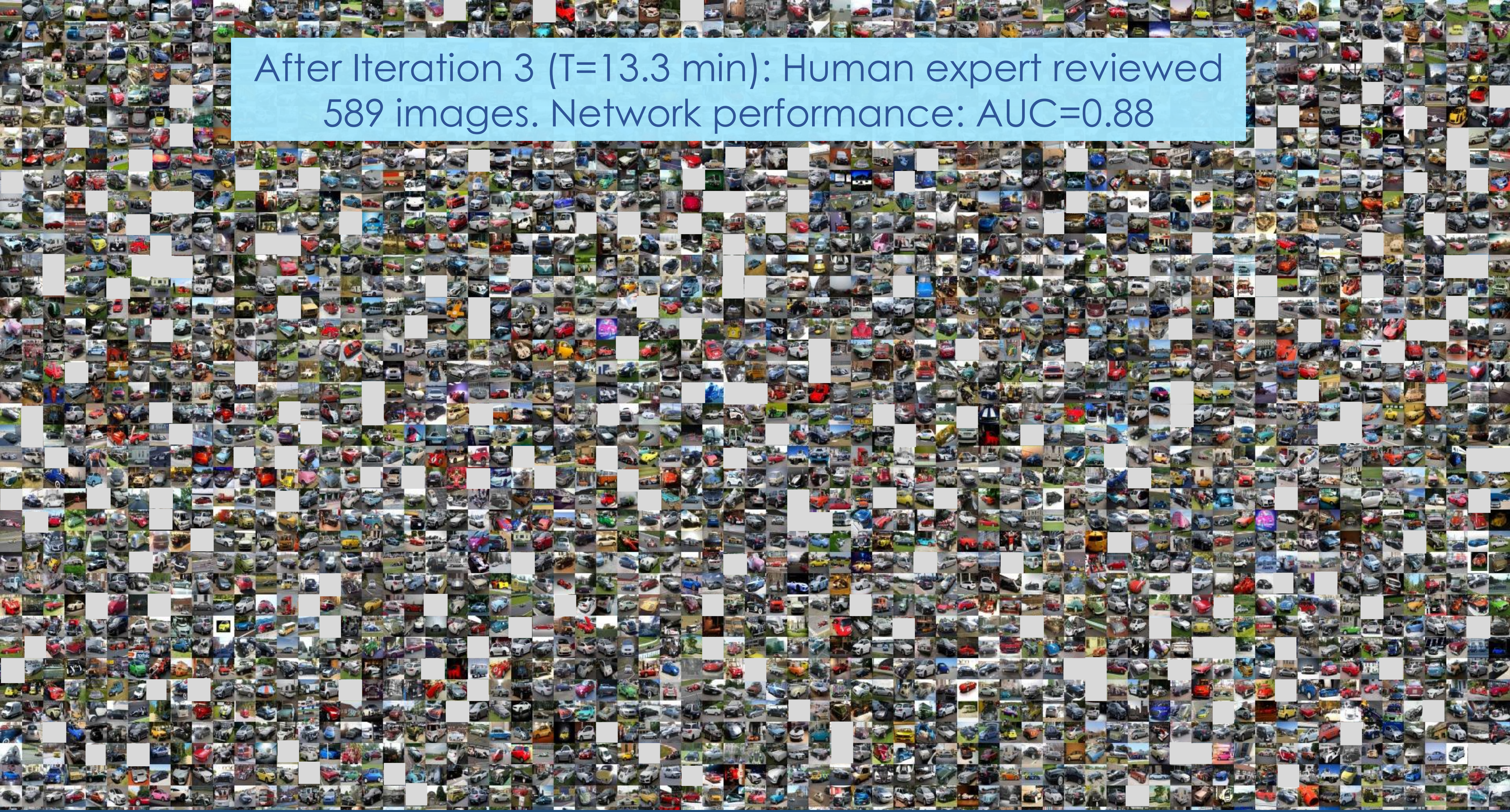
After Iteration 1 (T=4.2 min): Human expert reviewed 200 images. Network performance: AUC=0.8



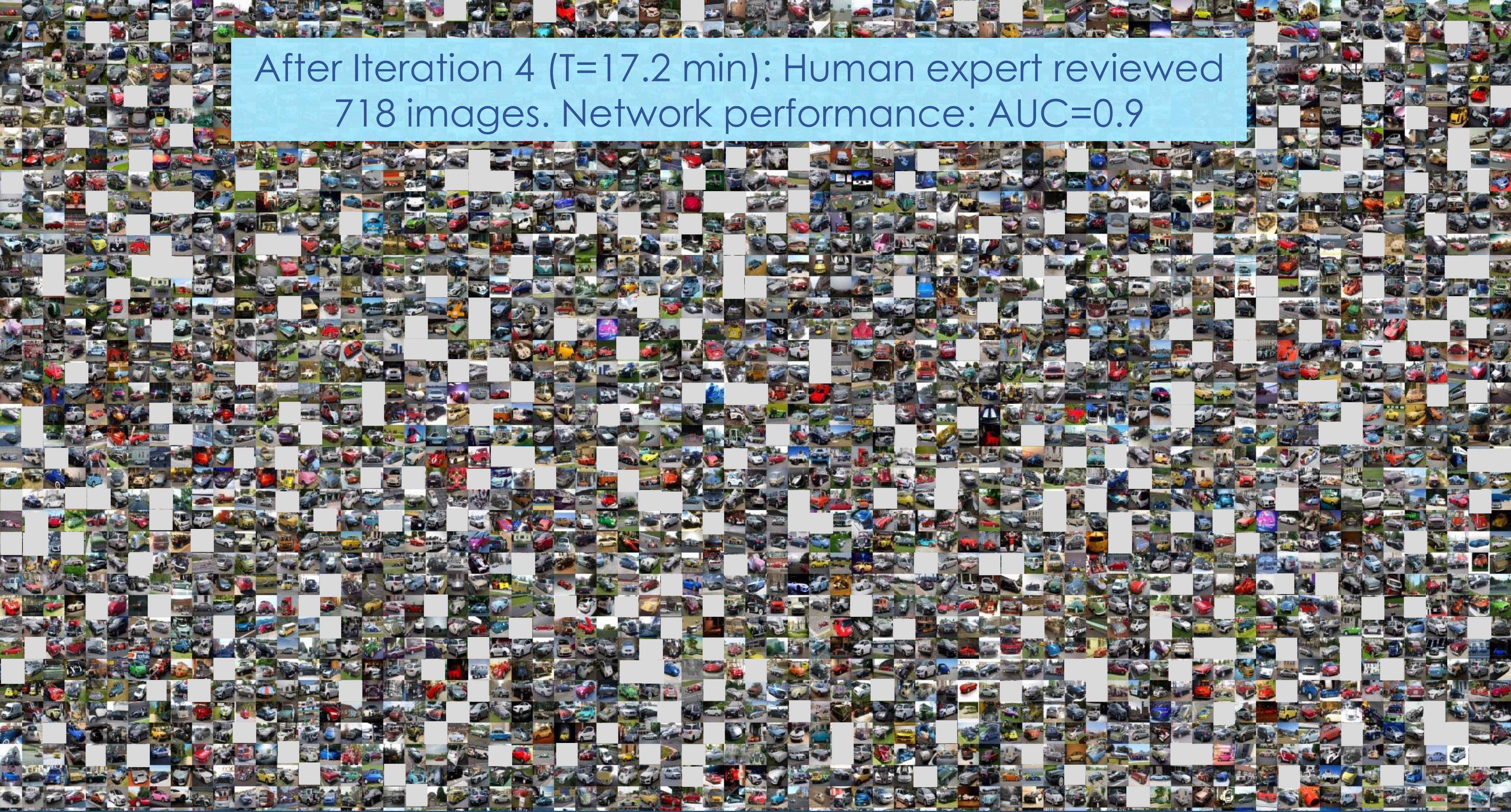
After Iteration 2 (T=8.7 min): Human expert reviewed 400 images. Network performance: AUC=0.86



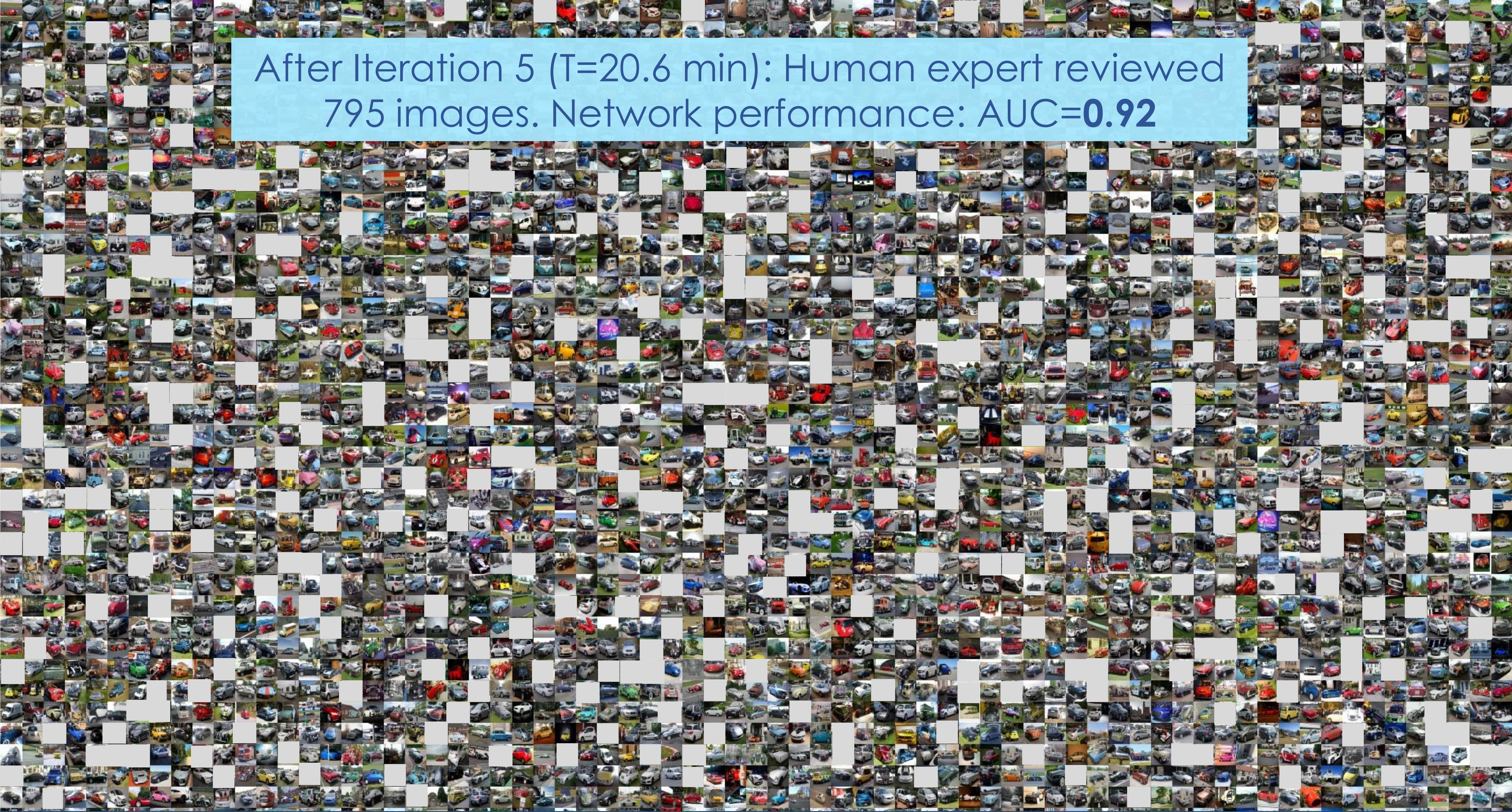
After Iteration 3 (T=13.3 min): Human expert reviewed 589 images. Network performance: AUC=0.88

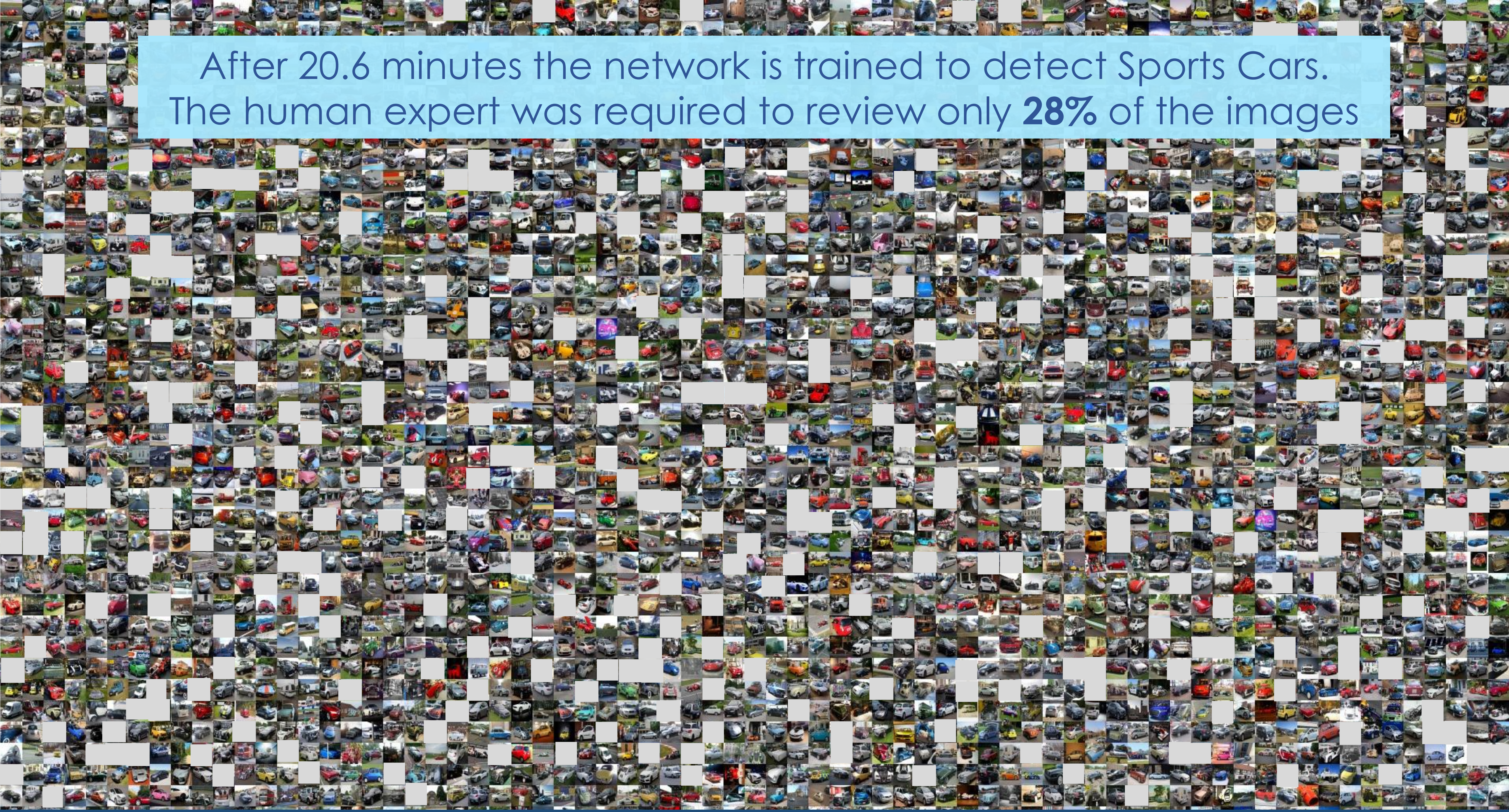


After Iteration 4 (T=17.2 min): Human expert reviewed 718 images. Network performance: AUC=0.9



After Iteration 5 (T=20.6 min): Human expert reviewed 795 images. Network performance: AUC=**0.92**

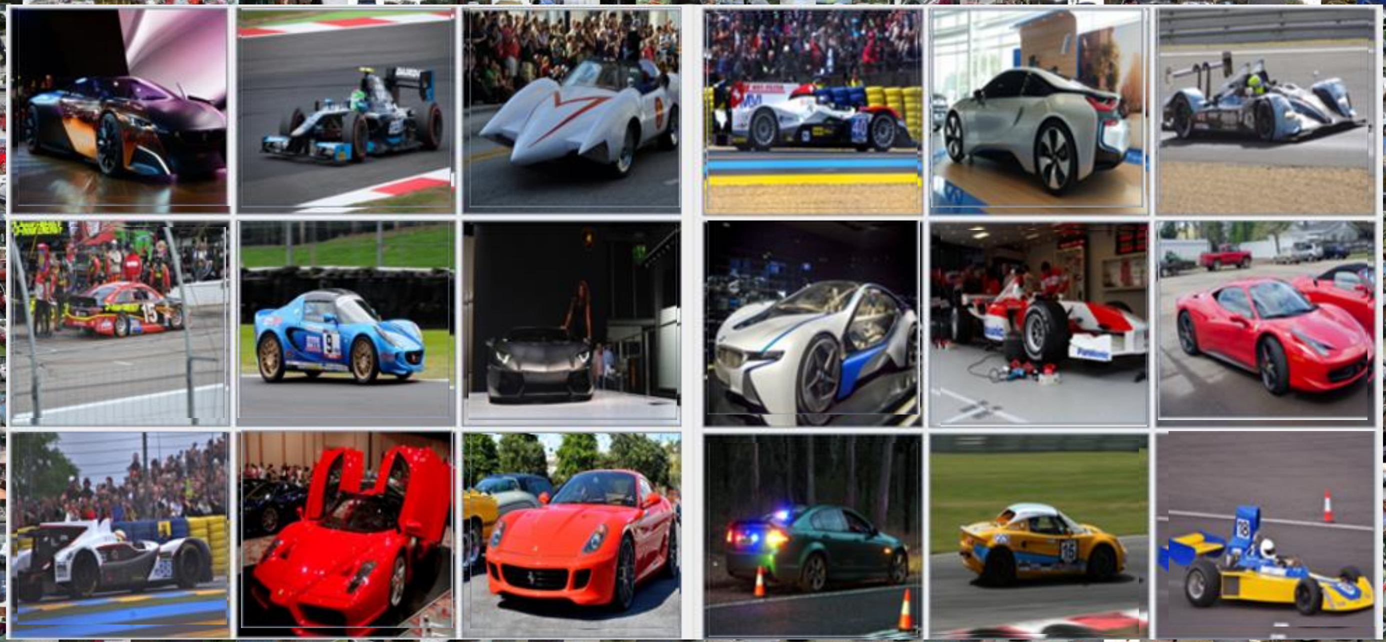




After 20.6 minutes the network is trained to detect Sports Cars.
The human expert was required to review only **28%** of the images

Examples of correctly classified sports cars:

Images with the highest score from the InnerEye system trained to classify Sport Cars:



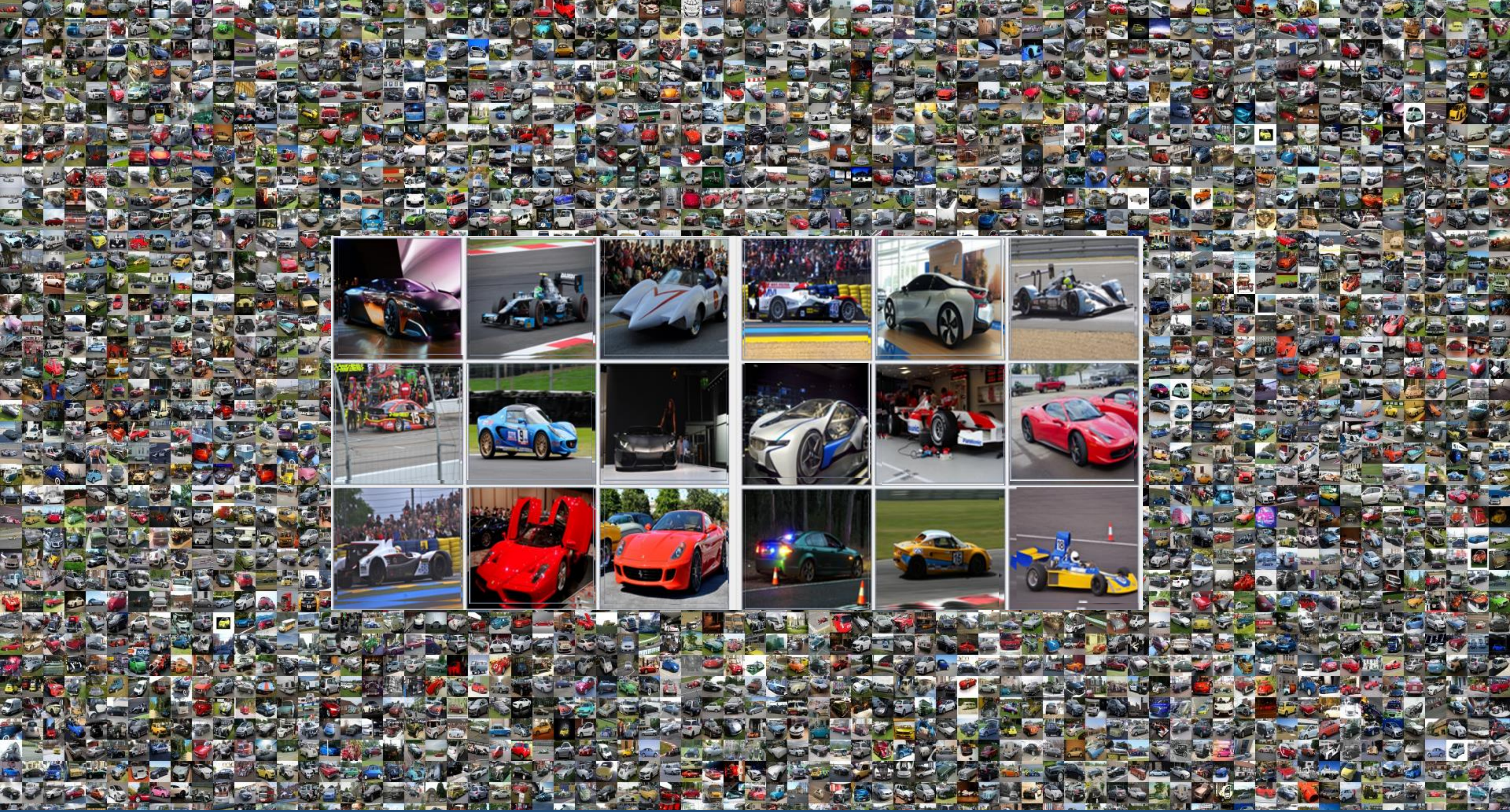
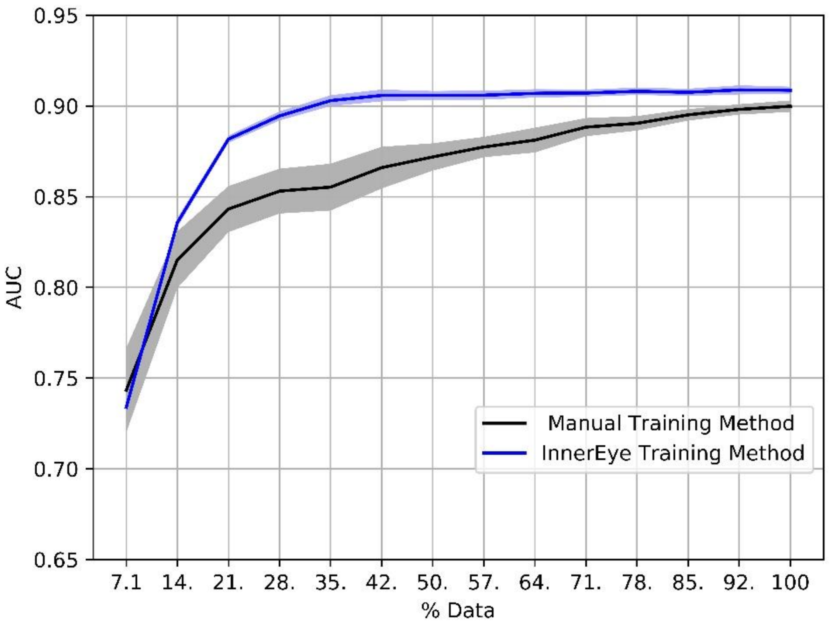
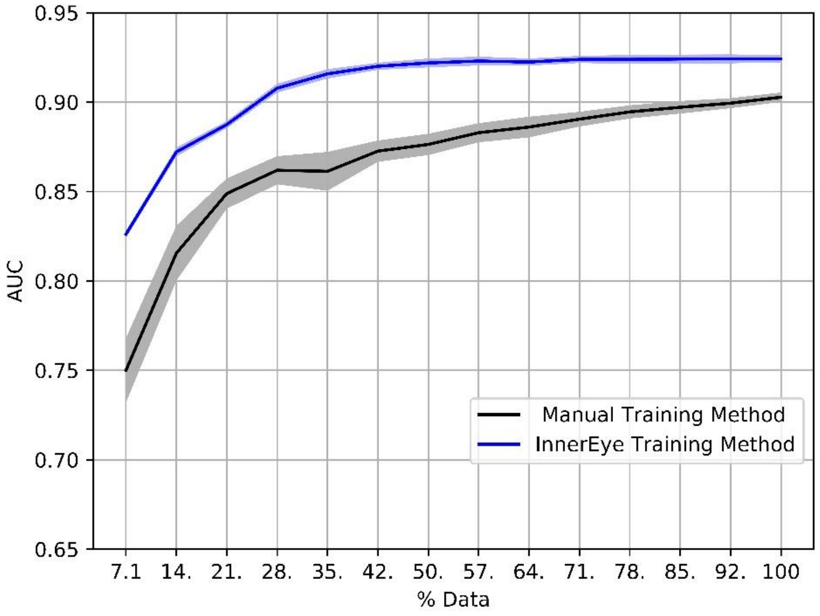


Image Classification Performance vs. % of Training Data

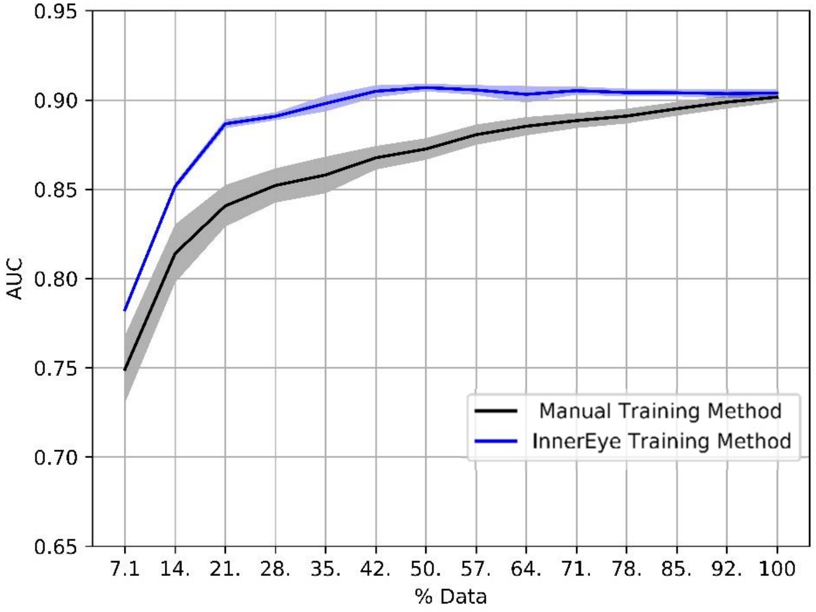
Subject 1



Subject 2



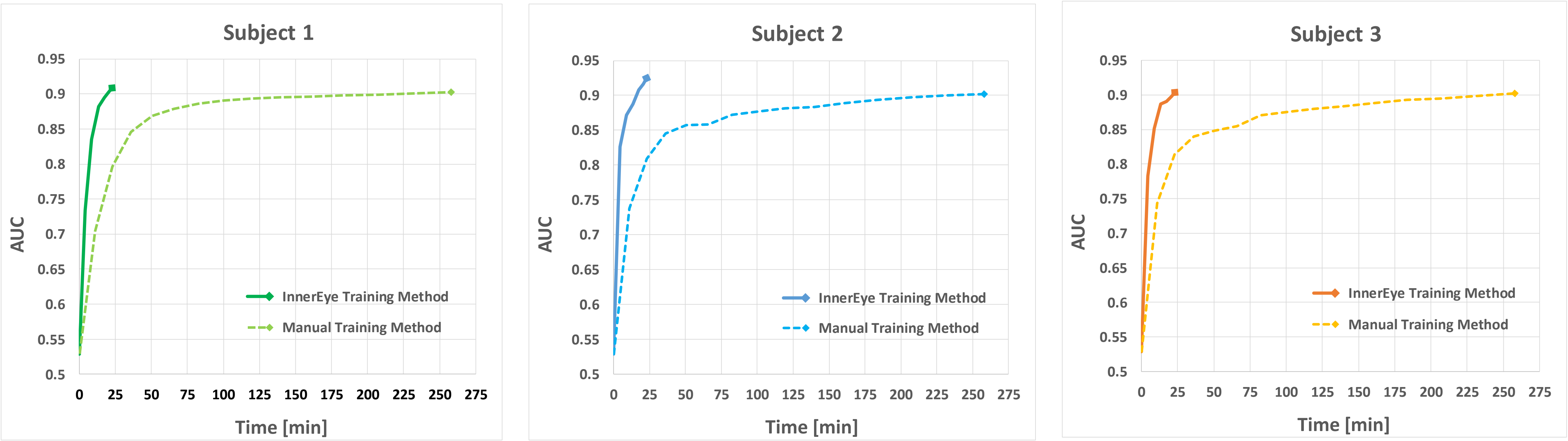
Subject 3



(*) AUC shown after the first iteration

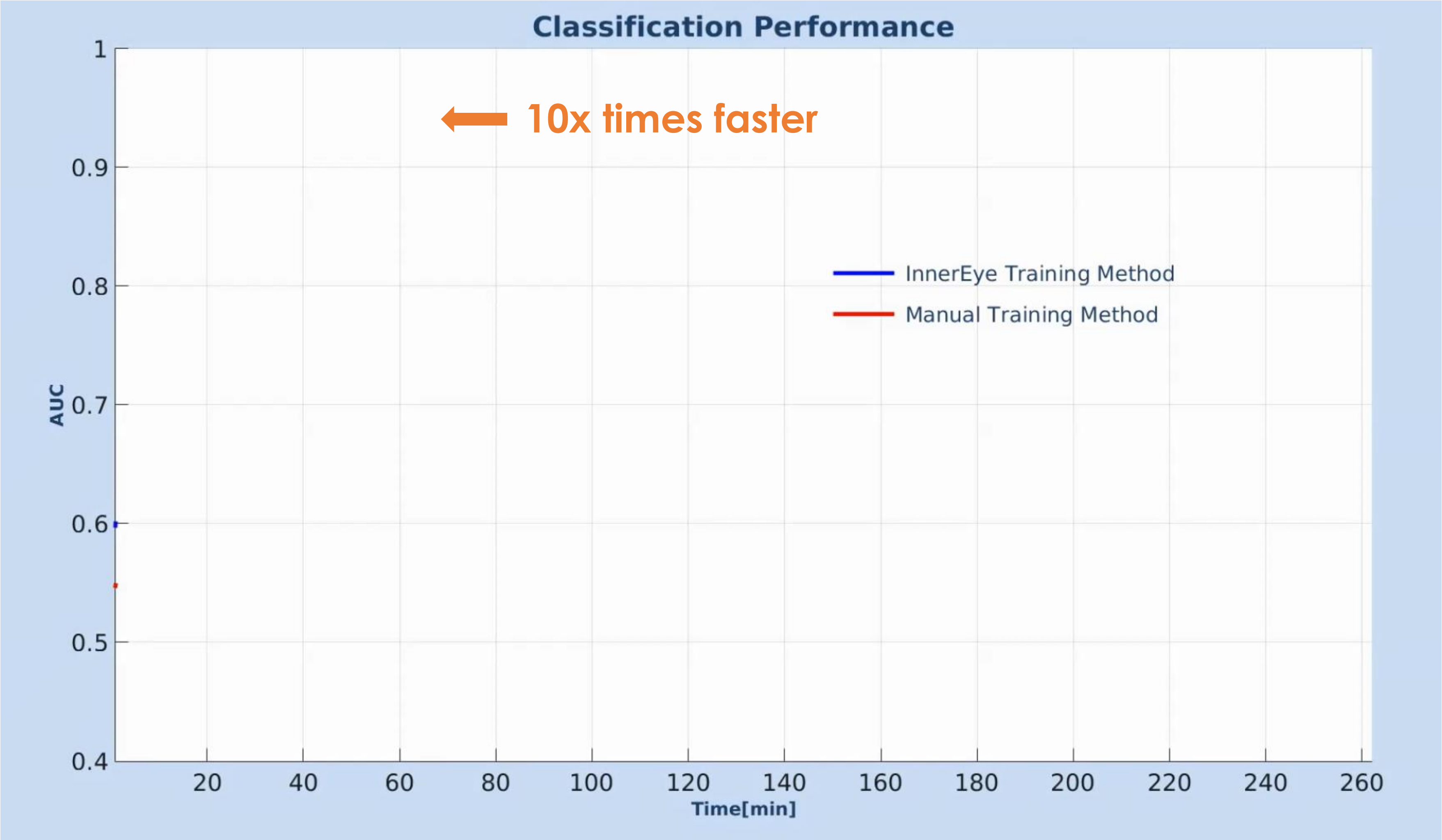
Image Classification Performance vs. Training Time

- Time savings come from combination of fast presentation rate and faster convergence



(*) Trained on NVIDIA GeForce GTX 1080 Ti

Image Classification Average Performance



Trained on NVIDIA GeForce GTX1080 ti GPU

Soft Labels Compensate for EEG Misclassified Samples

Correctly classified sports cars


Weight: 0.93


Weight: 0.81


Weight: 0.87

False Positives


Weight: 0.3


Weight: 0.26


Weight:0.22

Correctly classified regular cars


Weight: 0.85


Weight: 0.79


Weight: 0.91

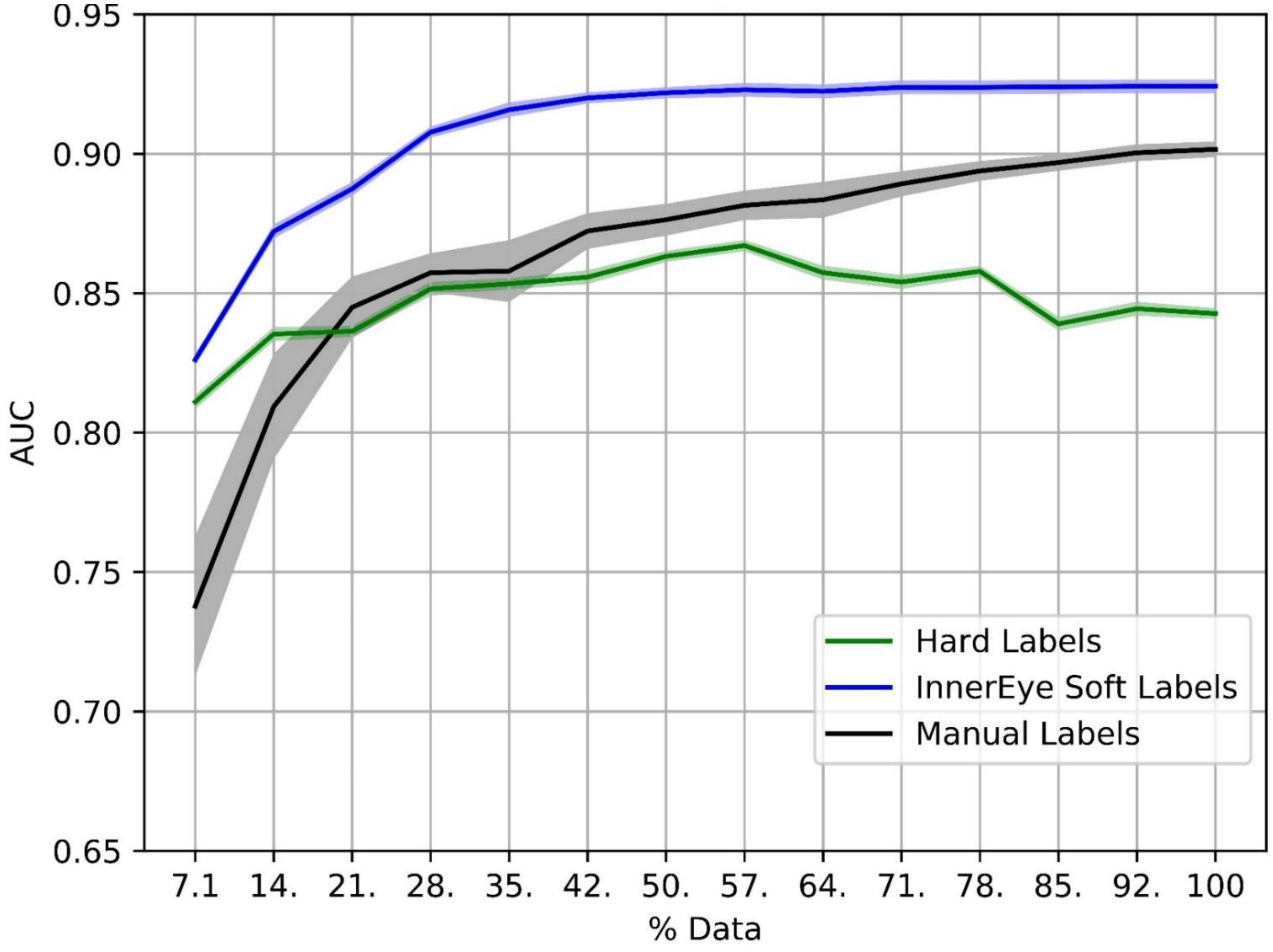
Missed sports cars

Weight: 0.4


Weight: 0.43


Weight: 0.31

Soft Labels Compensate for EEG Misclassified Samples



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Agenda

- Iterative AI Training Framework
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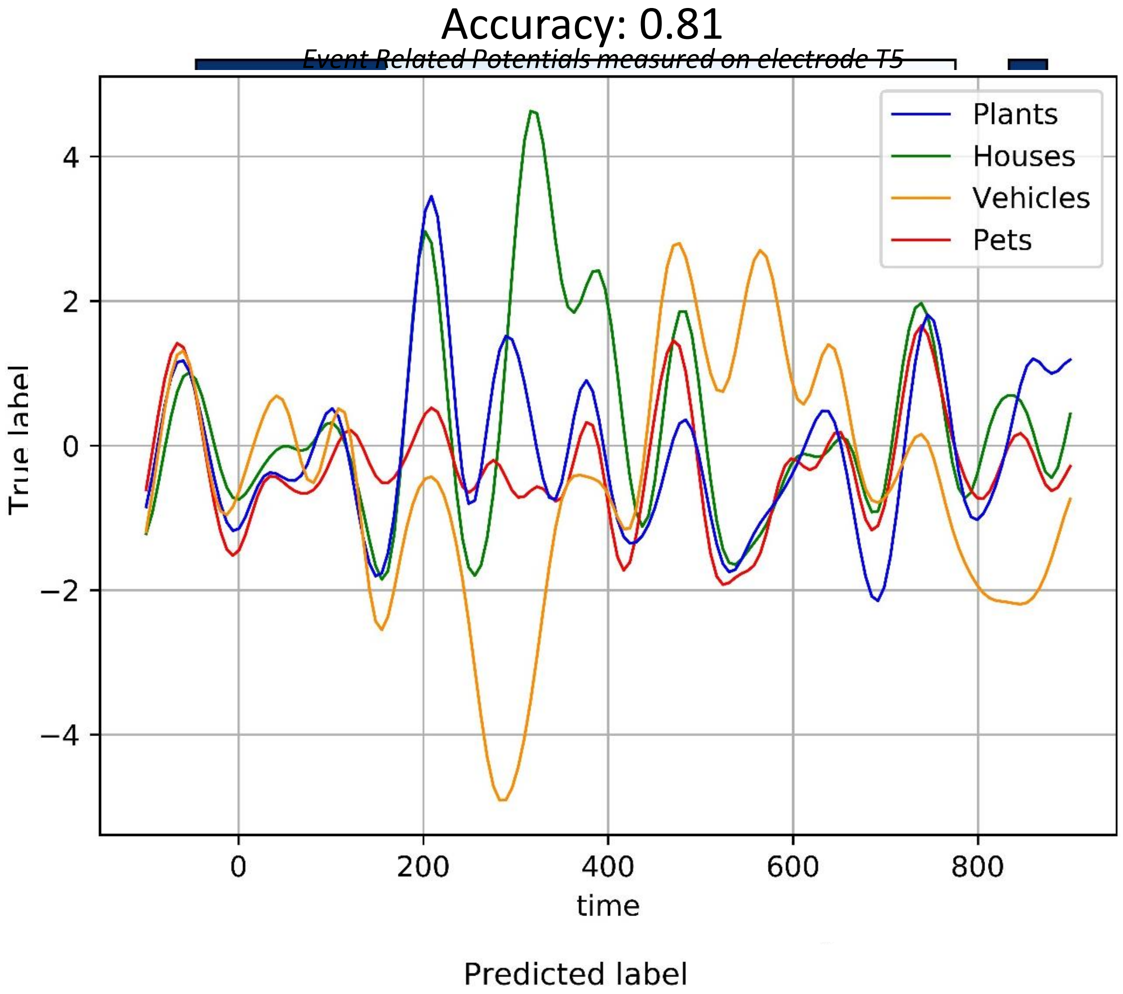
- Use Cases

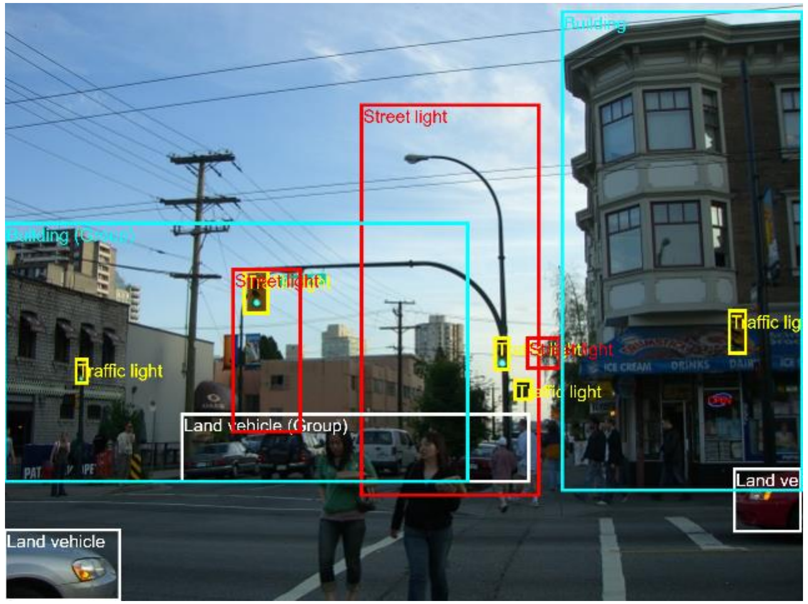
Multiclass Classification



Validation of Annotation Quality

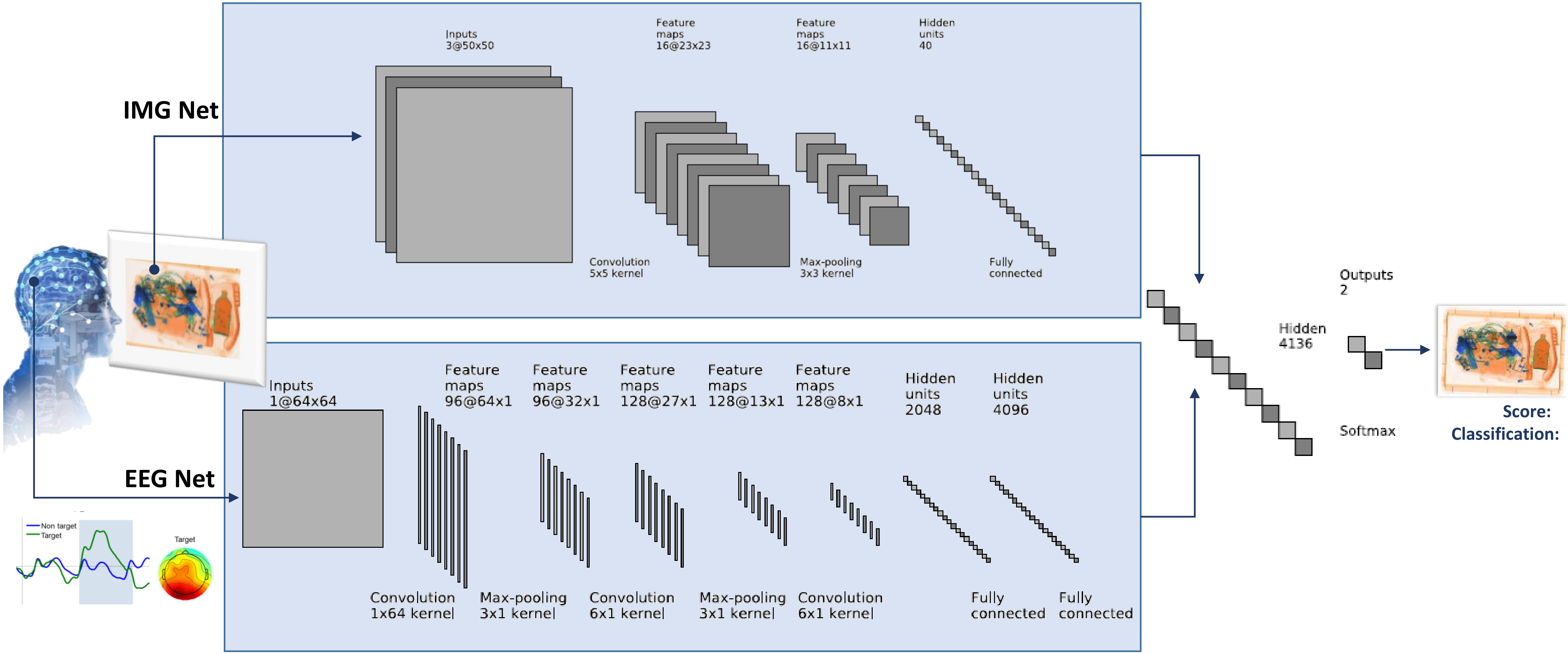
- Fast Screening and amendment of low confidence annotated data

Screenshot of the output from InnerEye system output of detecting images wrongly labeled as “flowers”



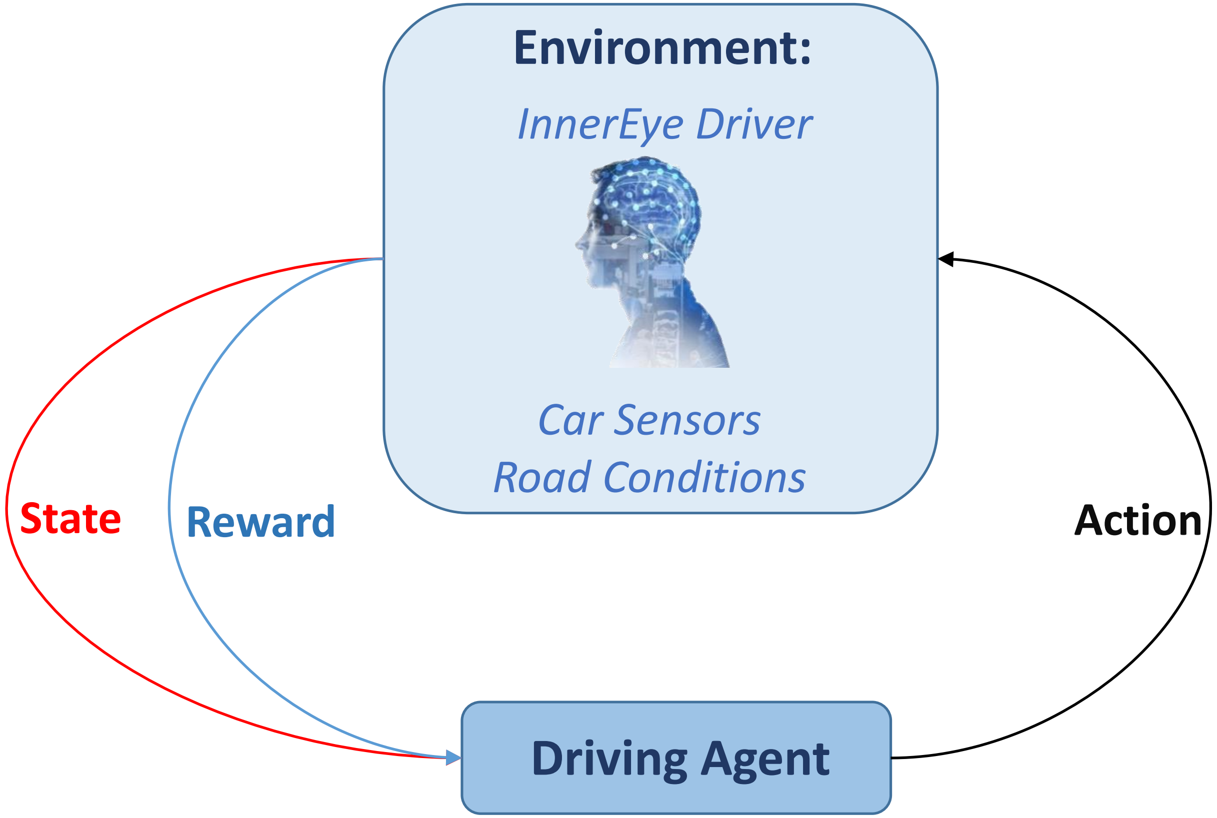
Source: Google Open Images Dataset

Combined Brain-Computer Visual Network



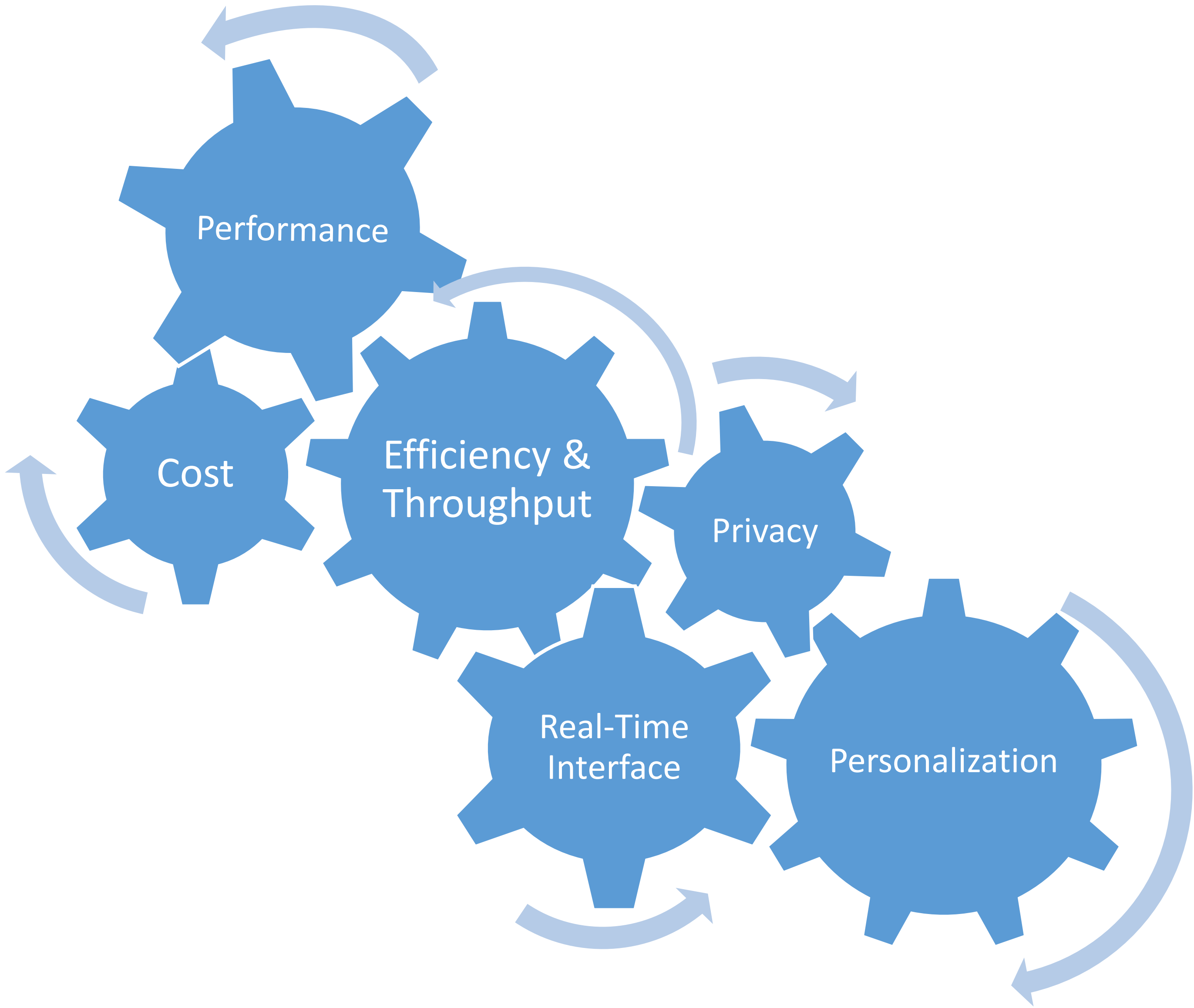
Reinforcement Learning for Autonomous Driving

- Incorporating brain insights in the training process of the AI driving agent



Screenshot of the output from "InnerEye driver" brain responding to seeing pedestrian crossing the road, measuring Hazard Detection, Attention and Emotion

Summary


Performance
Cost
Efficiency & Throughput
Privacy
Real-Time Interface
Personalization

THANK YOU!
COME SEE OUR DEMO AT BOOTH 335

Contact me at: **sergey@innereye.ai**