Learning Empathy-Driven Emotion Expressions using Affective Modulations

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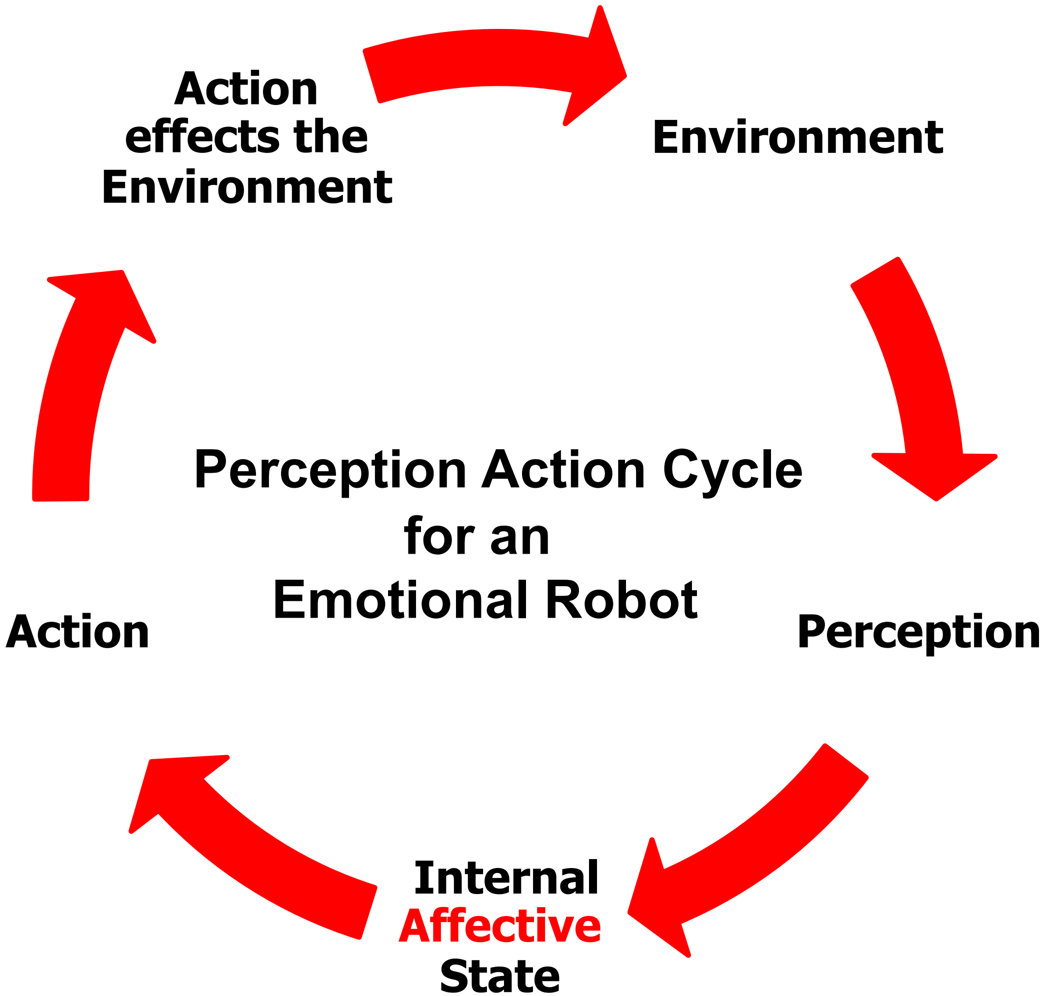
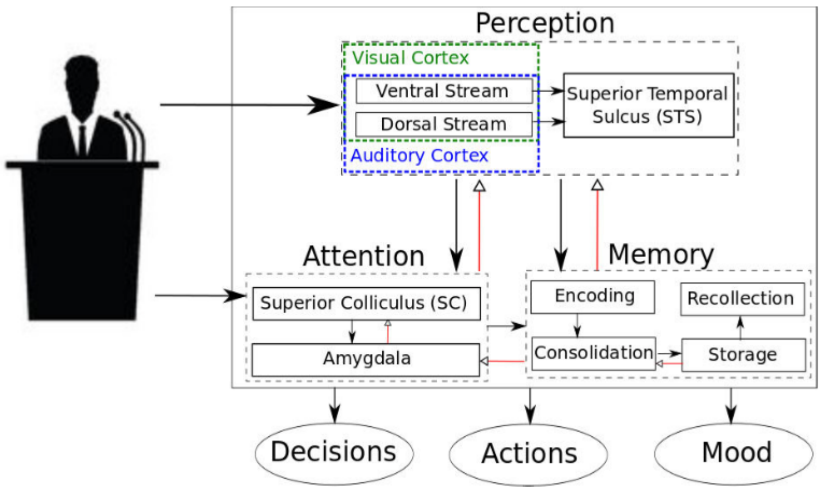
Motivation

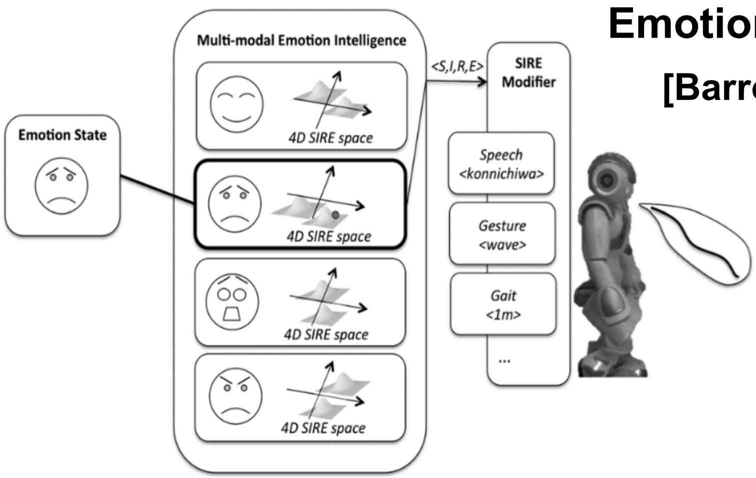

Action
effects the
Environment
Environment
Perception Action Cycle
for an
Emotional Robot
Action
Perception
Internal
Affective
State

Motivation



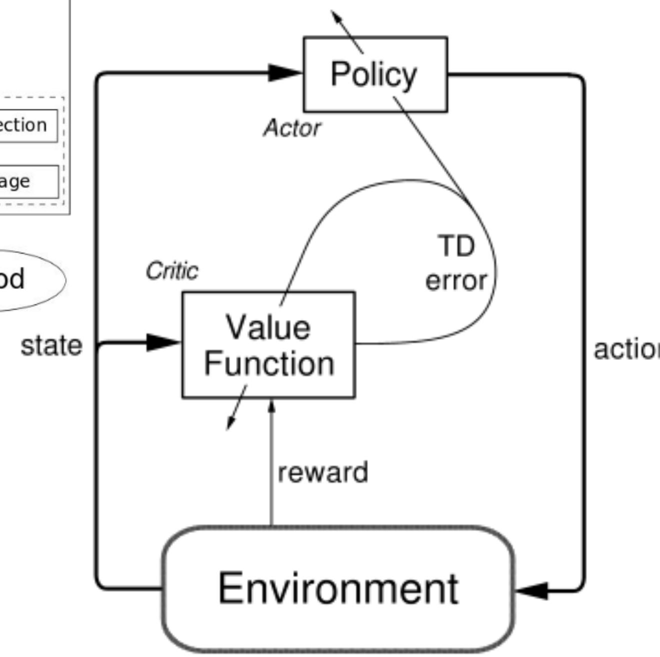
Emotion Circuitry

[Barros, 2016]



SIRE Model

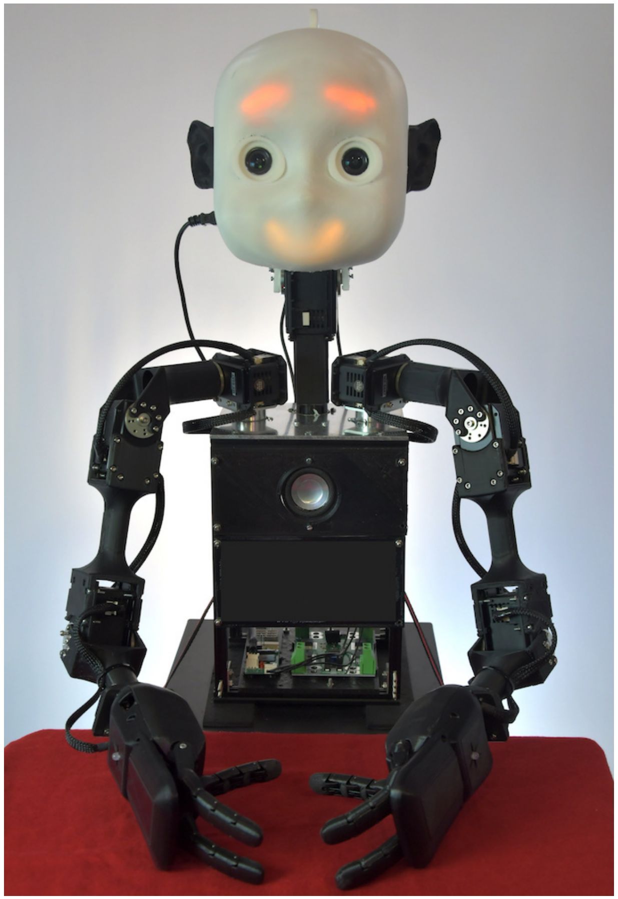
[Lim et al. 2014]

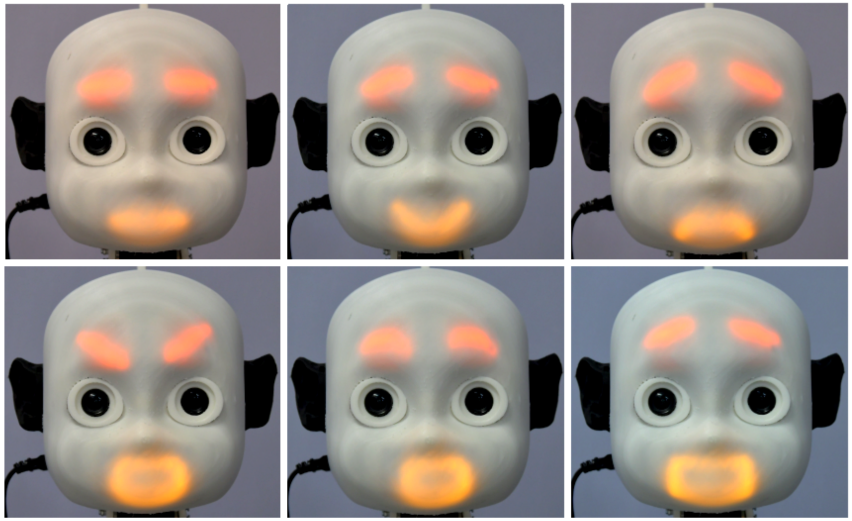


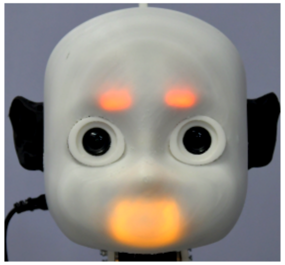
Actor-Critic Models for Reinforcement Learning

[Sutton & Barto, 1998]

NICO: Neuro-Inspired Companion





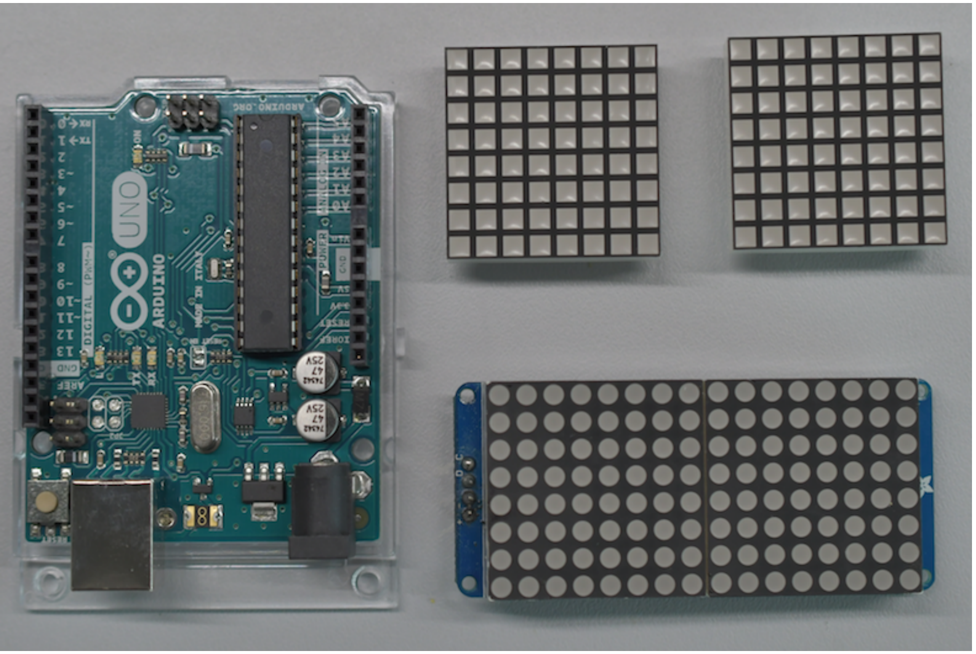


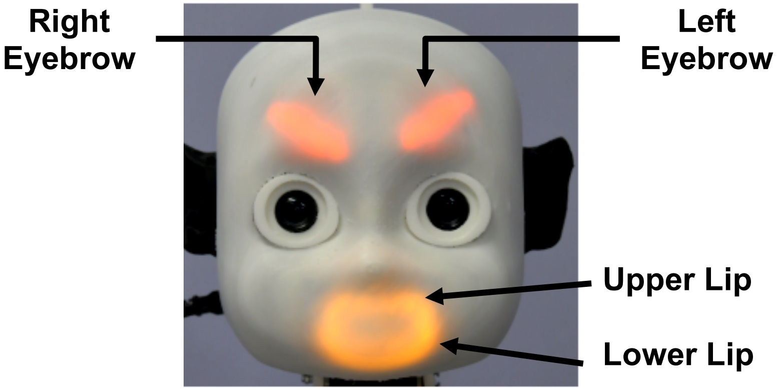
NICO displaying facial expression for seven basic emotions: neutral, happiness, sadness, anger, surprise, fear and disgust.

[Churamani et. al 2017]
[Kerzel et al. 2017]

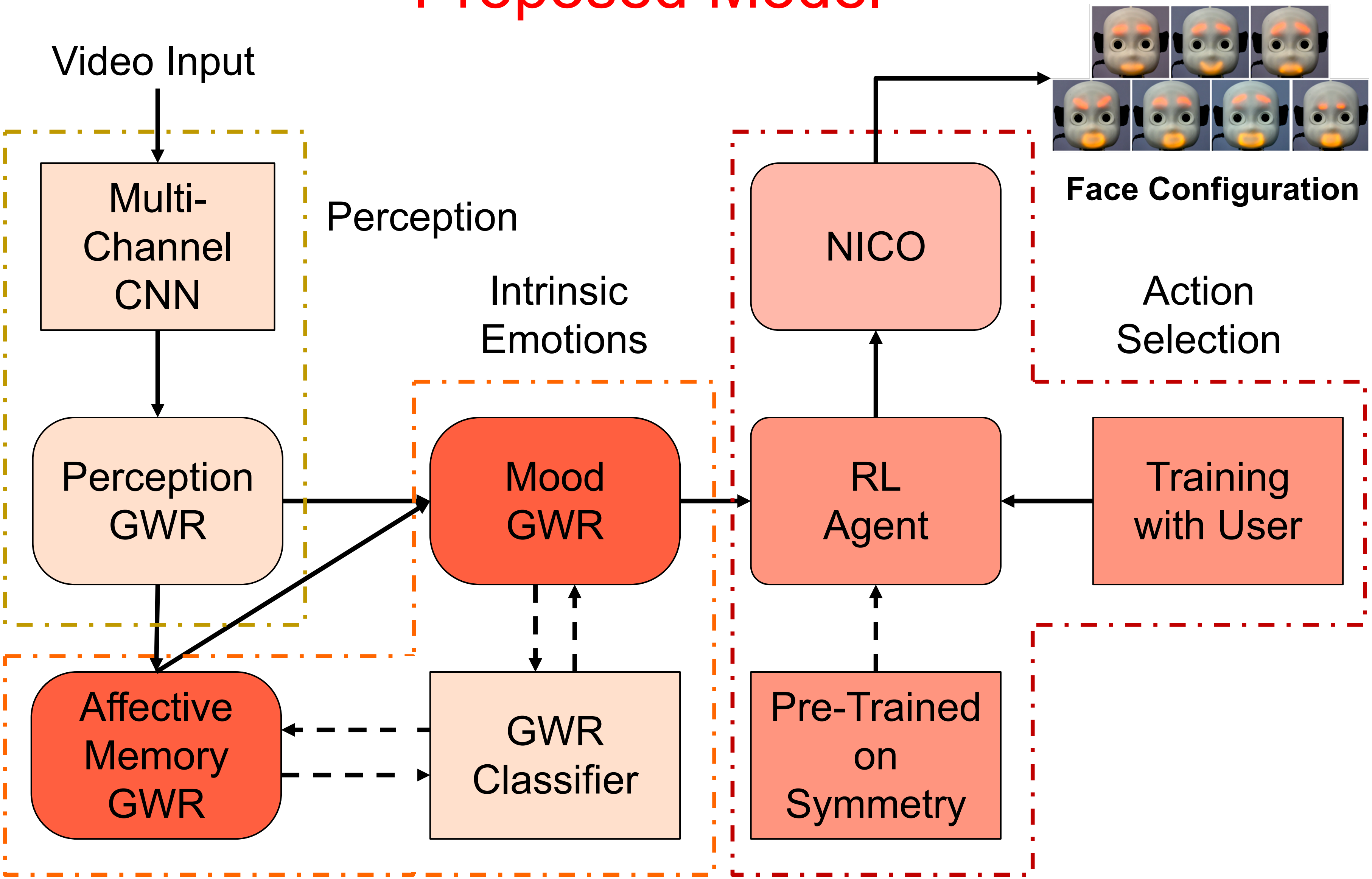
NICO: Neuro-Inspired Companion

*Each Wavelet: [yStretch, yOffset, xStretch, xOffset]

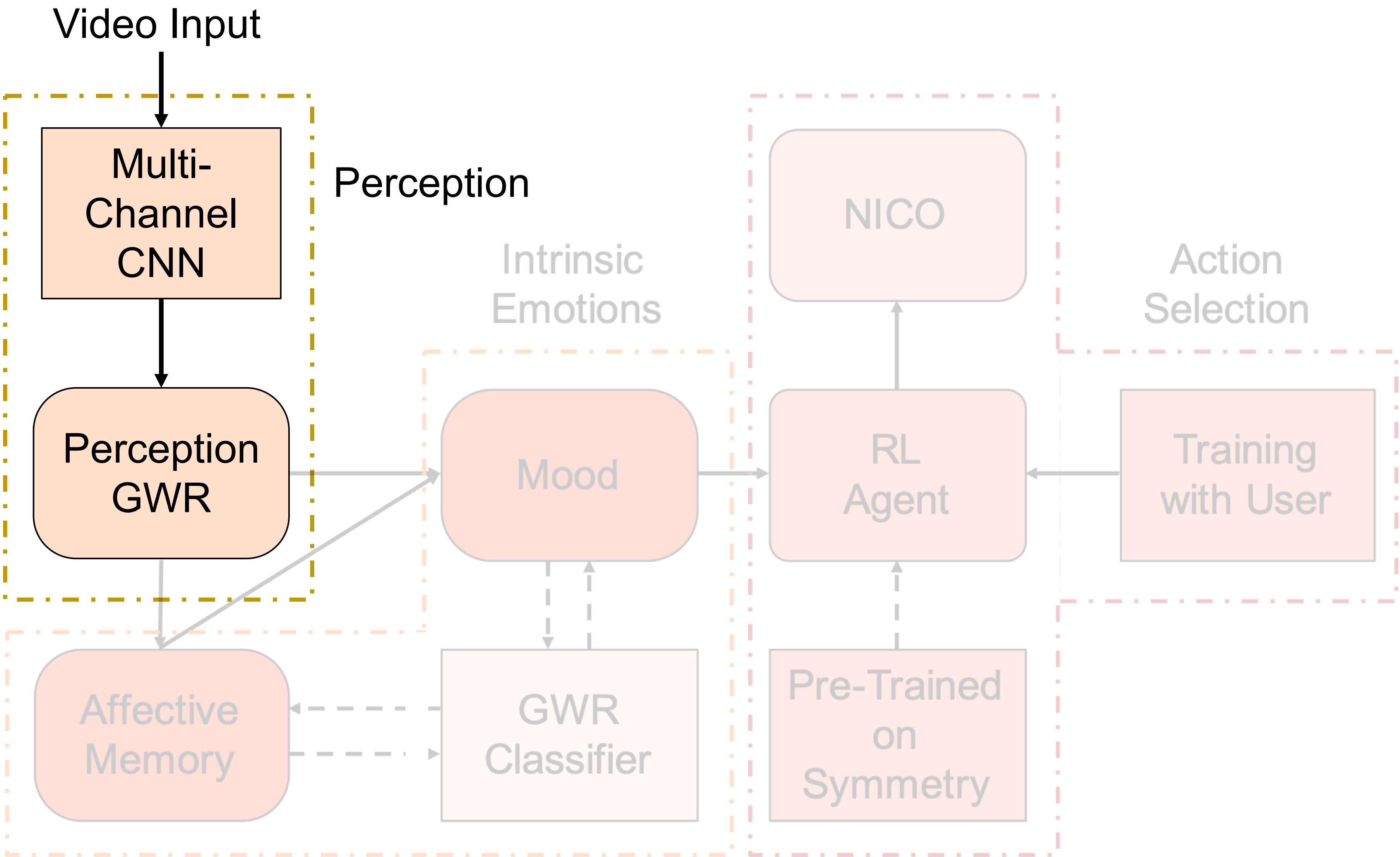




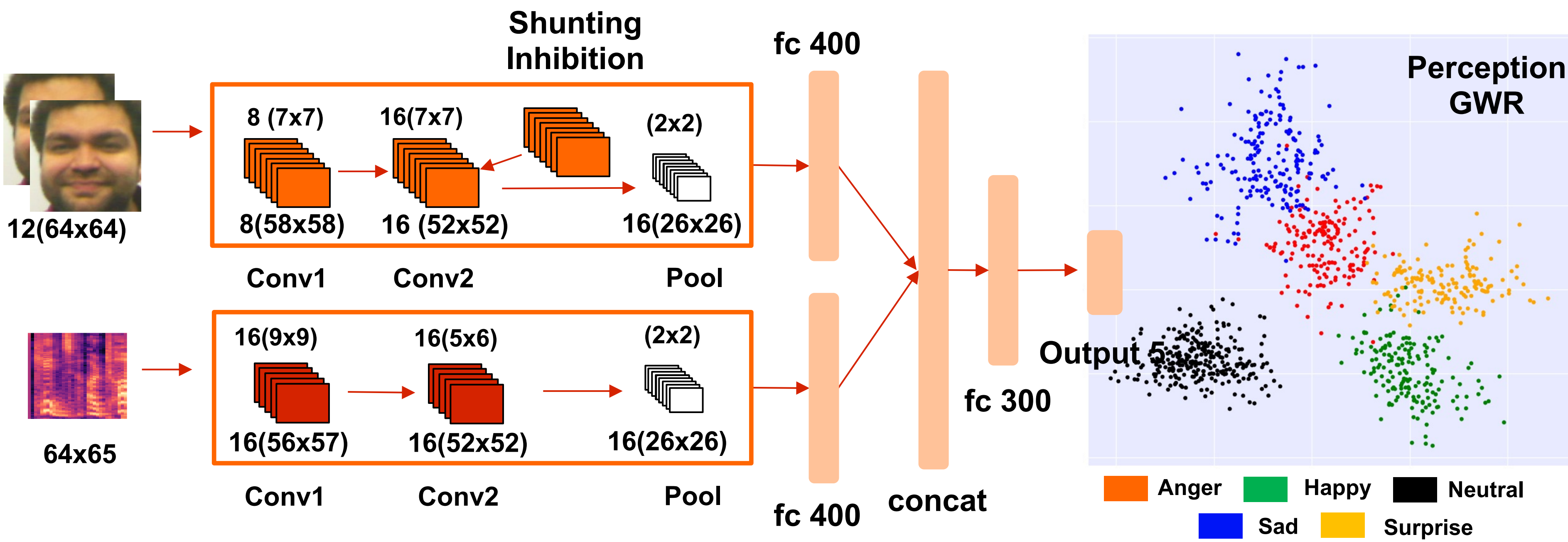
Proposed Model



Emotion Perception



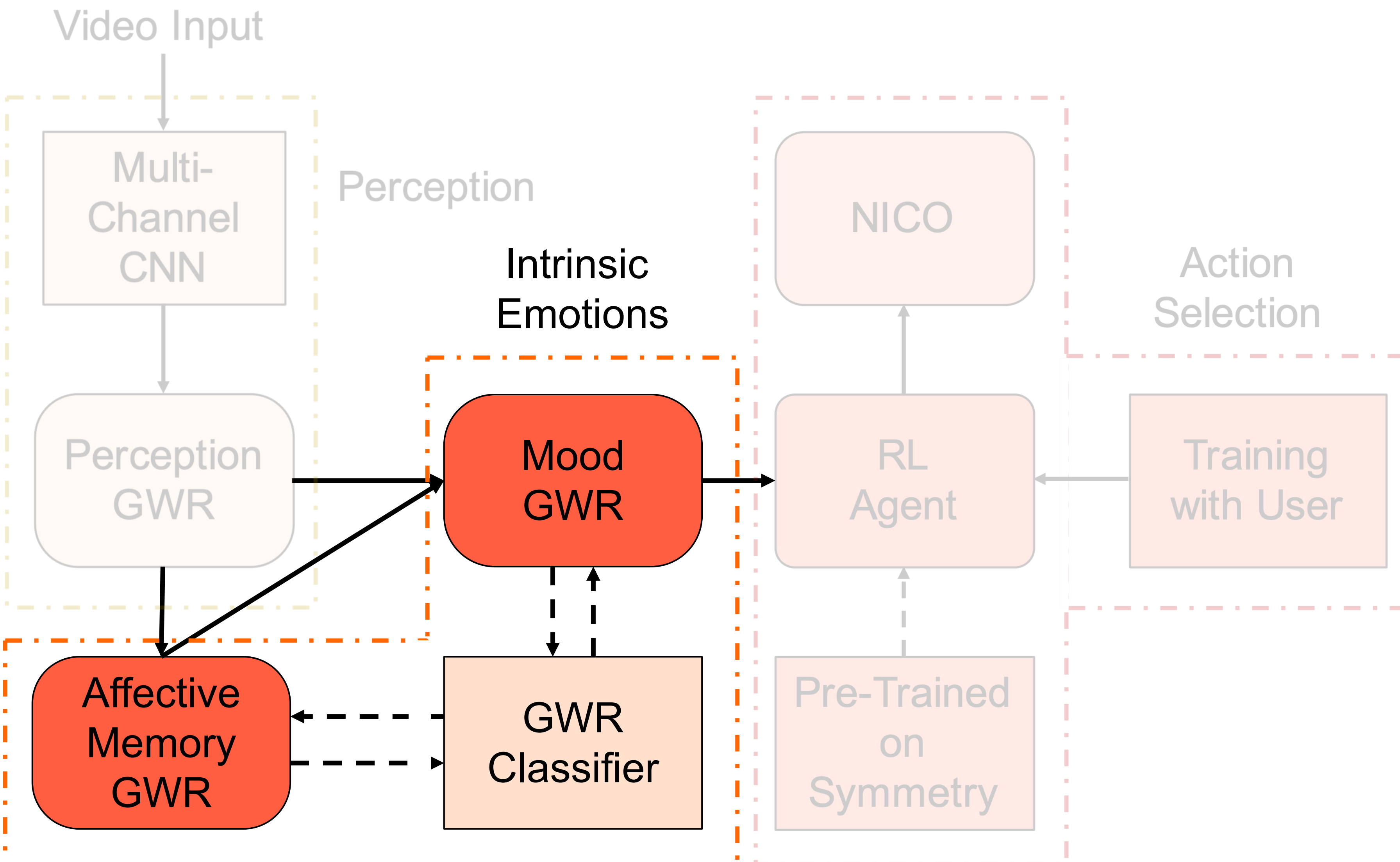
Emotion Perception



Multi-Channel Convolutional Neural Network

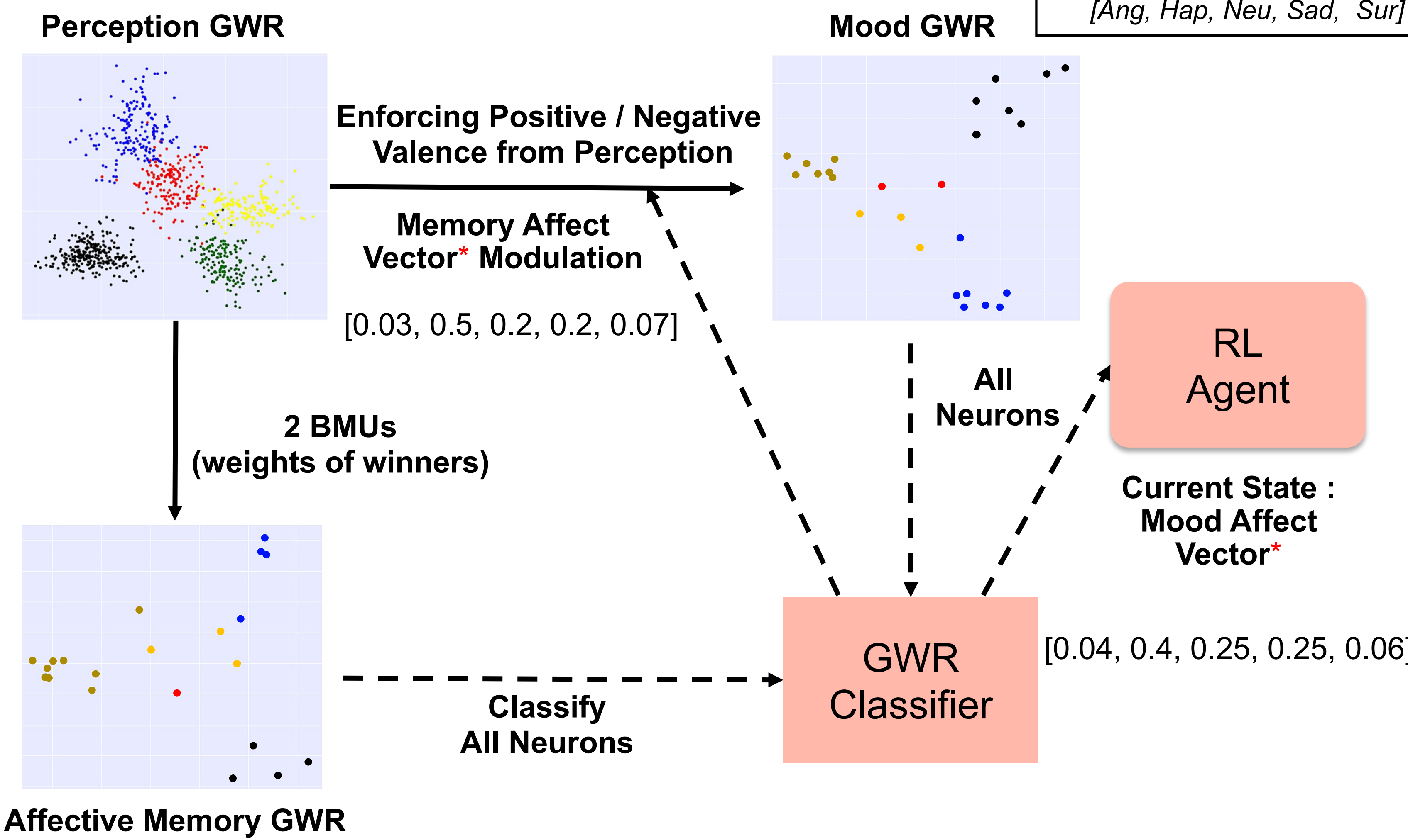
Perception GWR Network

Intrinsic Emotions

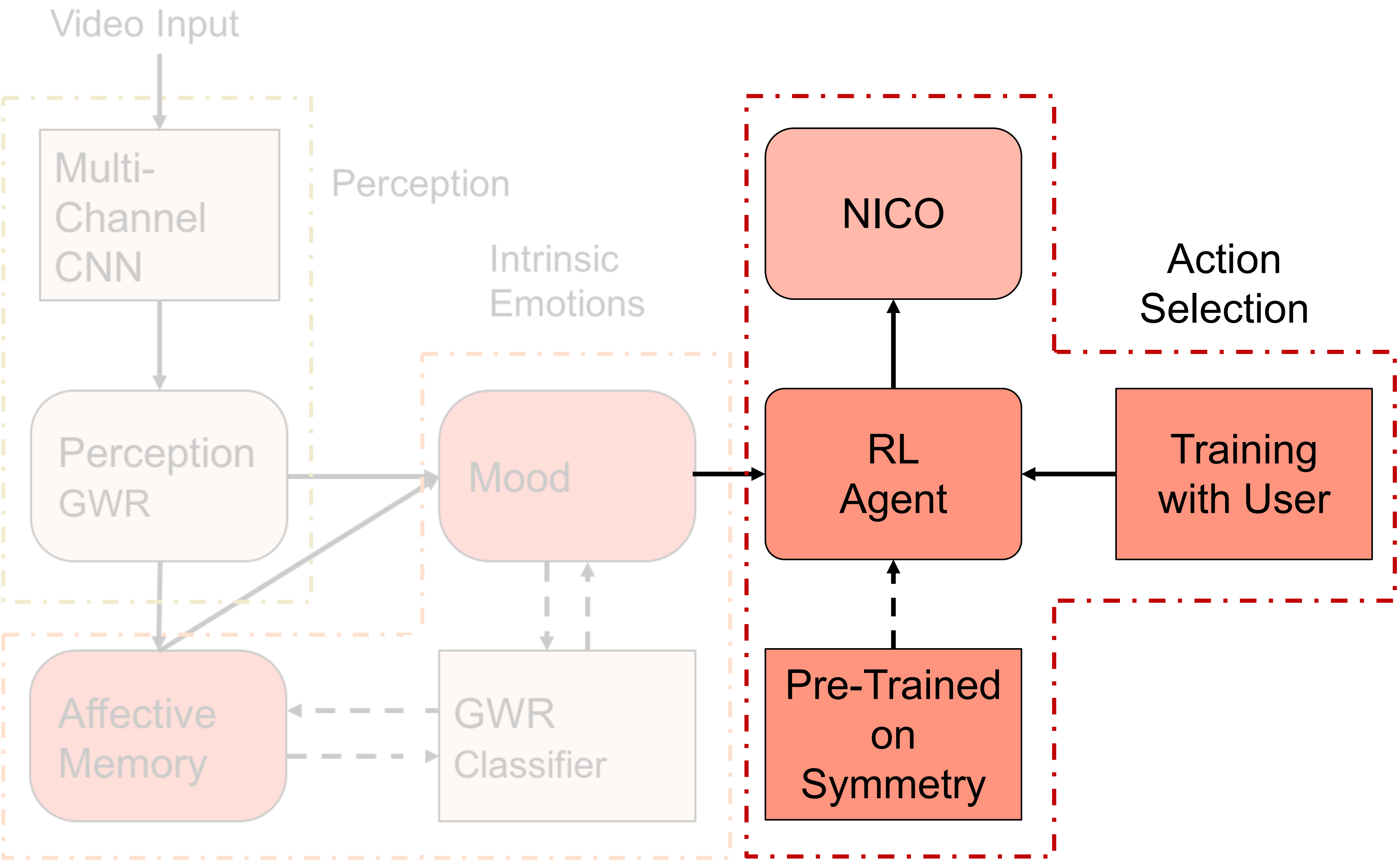


Intrinsic Emotions

** Affect Vector encodes the fraction of neurons corresponding to each emotion constituting the GWR.*
Eg. Angry Heavy Memory:
[0.5, 0.1, 0.2, 0.15, 0.05]
[Ang, Hap, Neu, Sad, Sur]



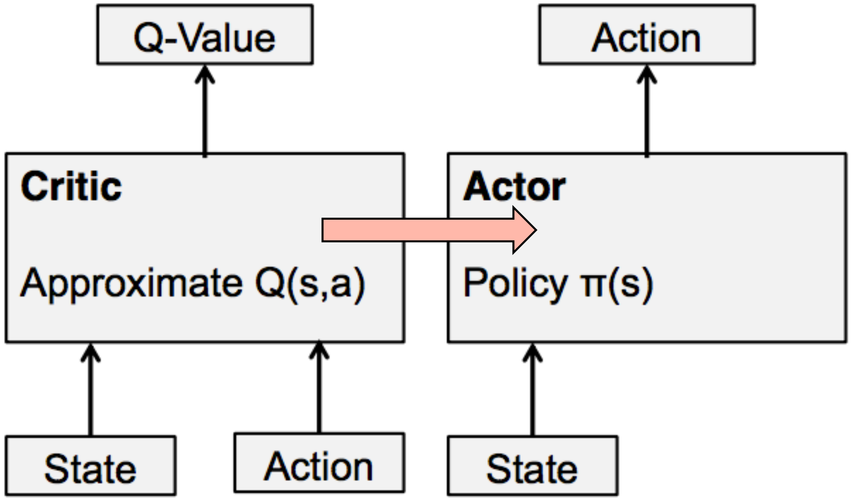
Learning To Express



Learning To Express

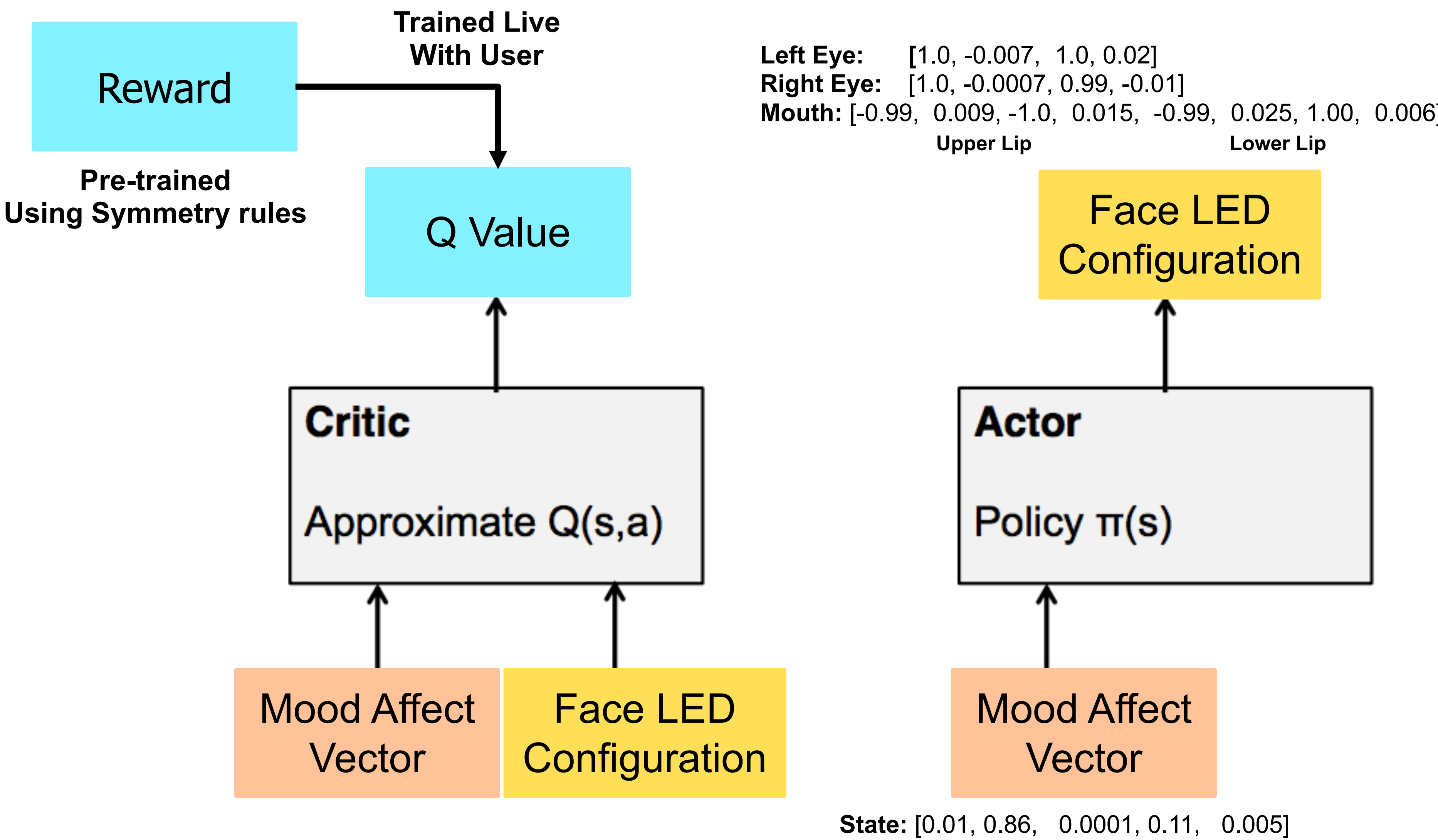
(Reinforcement Learning in Continuous Domain)

- Deep Deterministic Policy Gradients
- Extension of DQN [Mnih et al. 2015] to continuous actions [Lillicrap et al. 2015] :
  - Separate networks trained using gradient transfer
  - Tracked updates – enhance stability at the cost of learning speed
  - Replay memory – decouples learning episodes

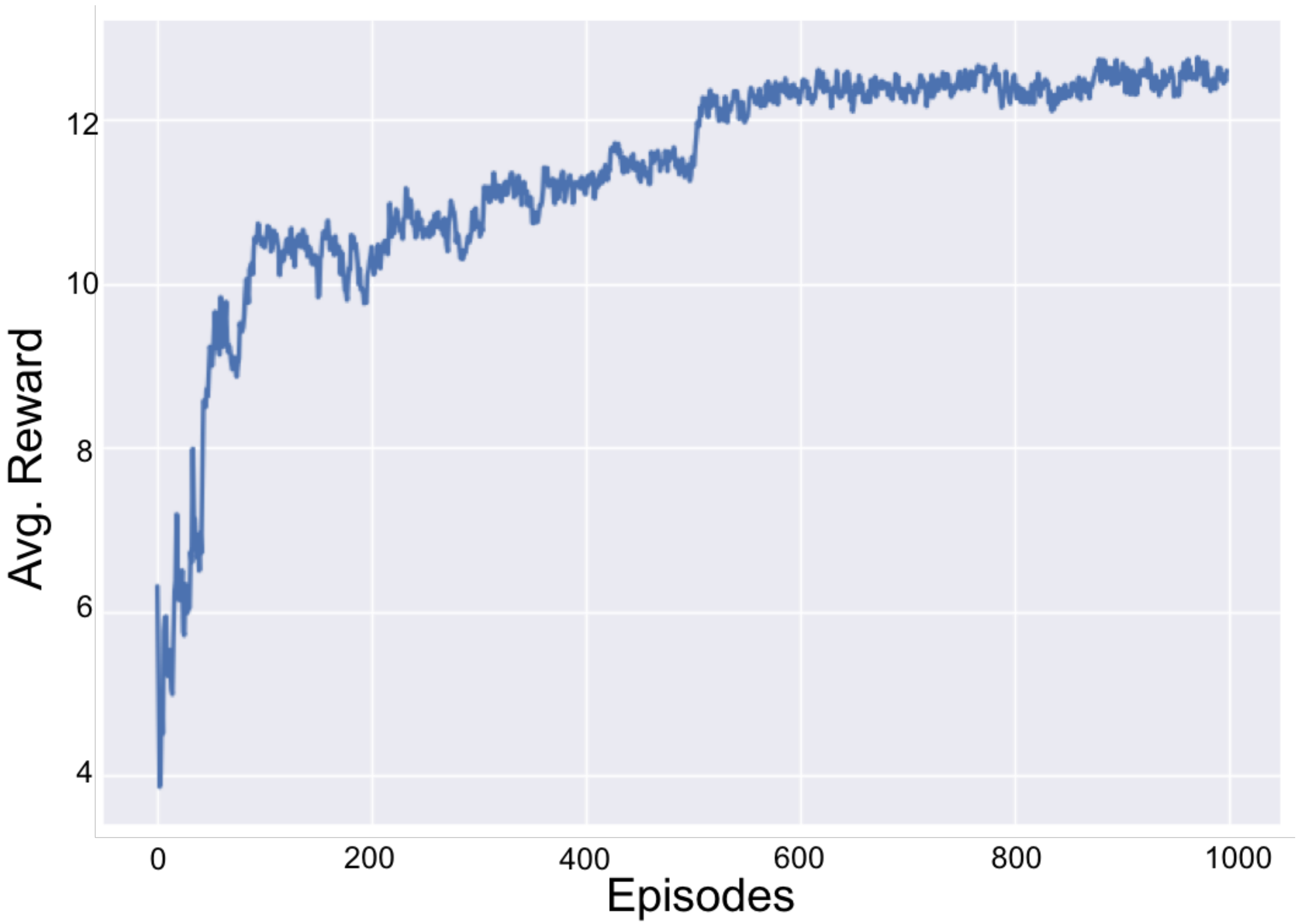


*Each Wavelet: [yStretch, yOffset, xStretch, xOffset]

Learning To Express

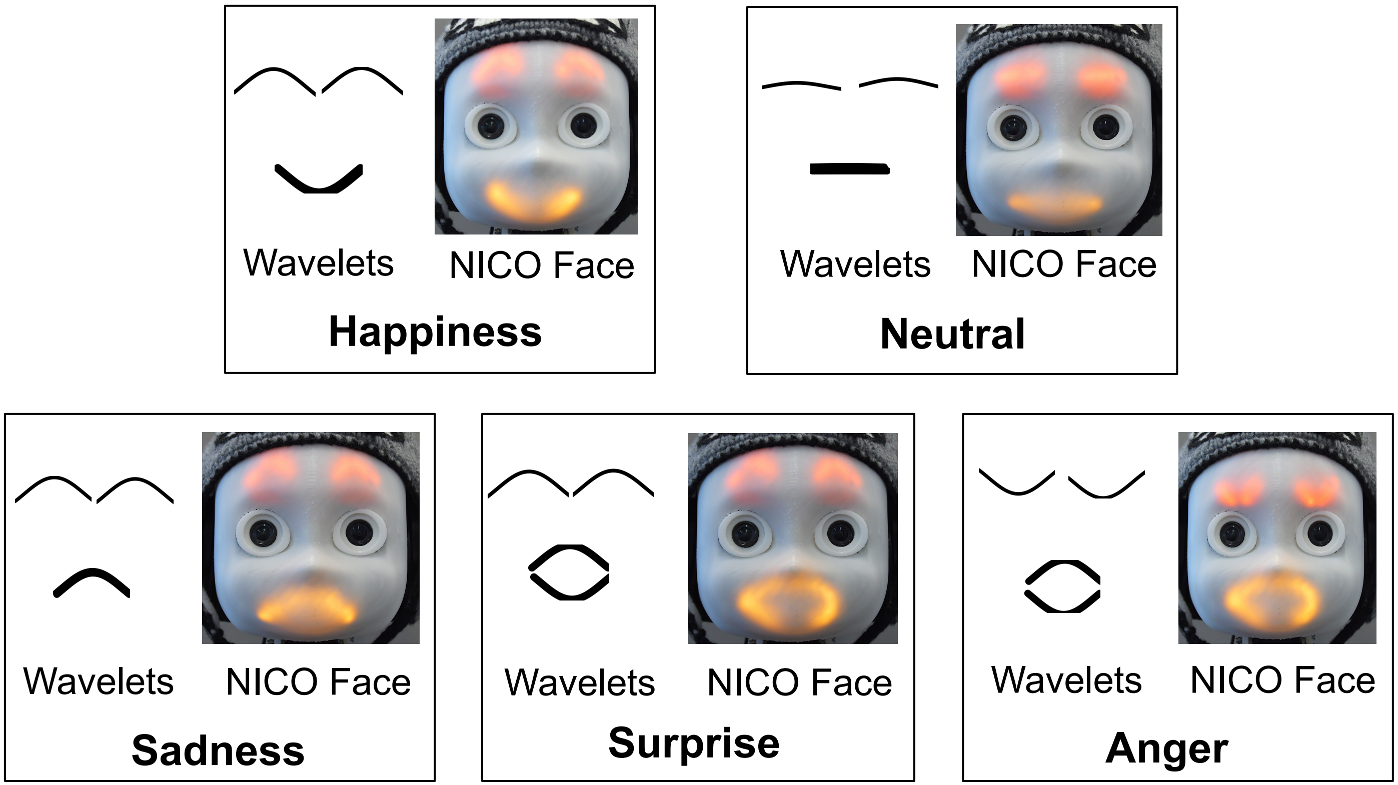


Results



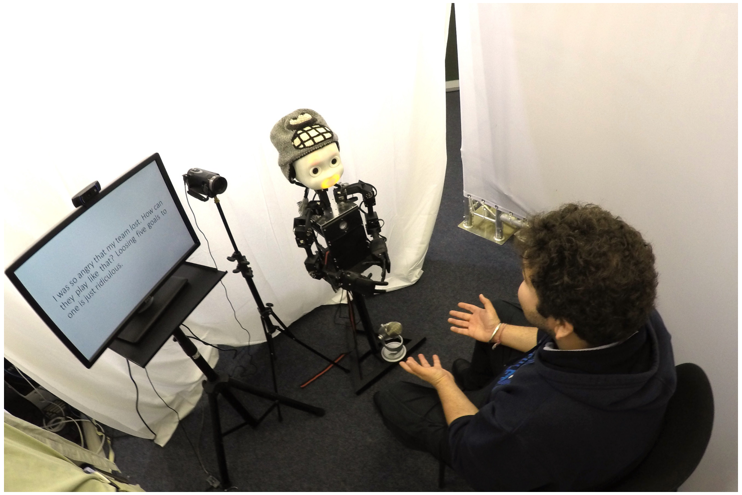
Rewarding Symmetry

Result: NICO Faces



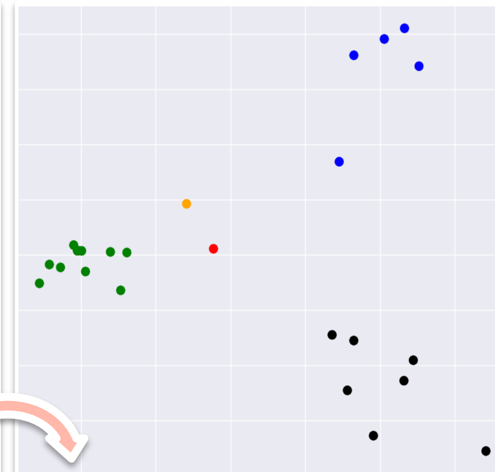
Learning with Users: Setup

- Training with 6 participants.
- Each participant trains the robot by telling a story after reading and memorising from the screen.
  - The story is split into 21 interaction dialogues.
  - Each dialogue presents 5-6 seconds of audio-visual input after which the robot reacts.
- For testing purposes another story is narrated to the robot consisting of 10 interaction dialogues.



Learning with Users: Scenario

User Narrates a story to the robot with an affective context.



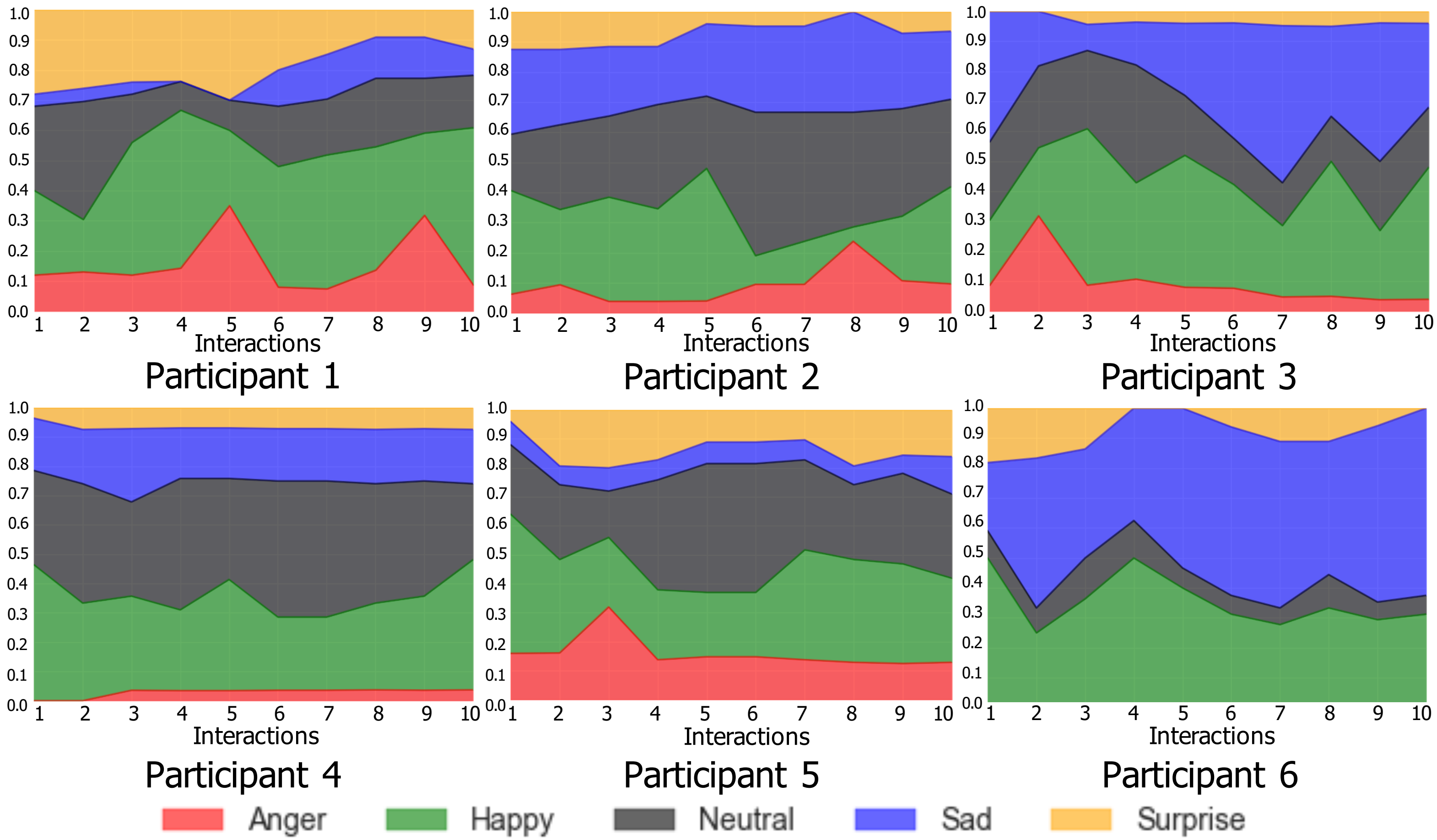
Robot forms an intrinsic affective model of the interaction.

NICO generates a Face Expression it deems appropriate.

Participant Evaluation: Inappropriate

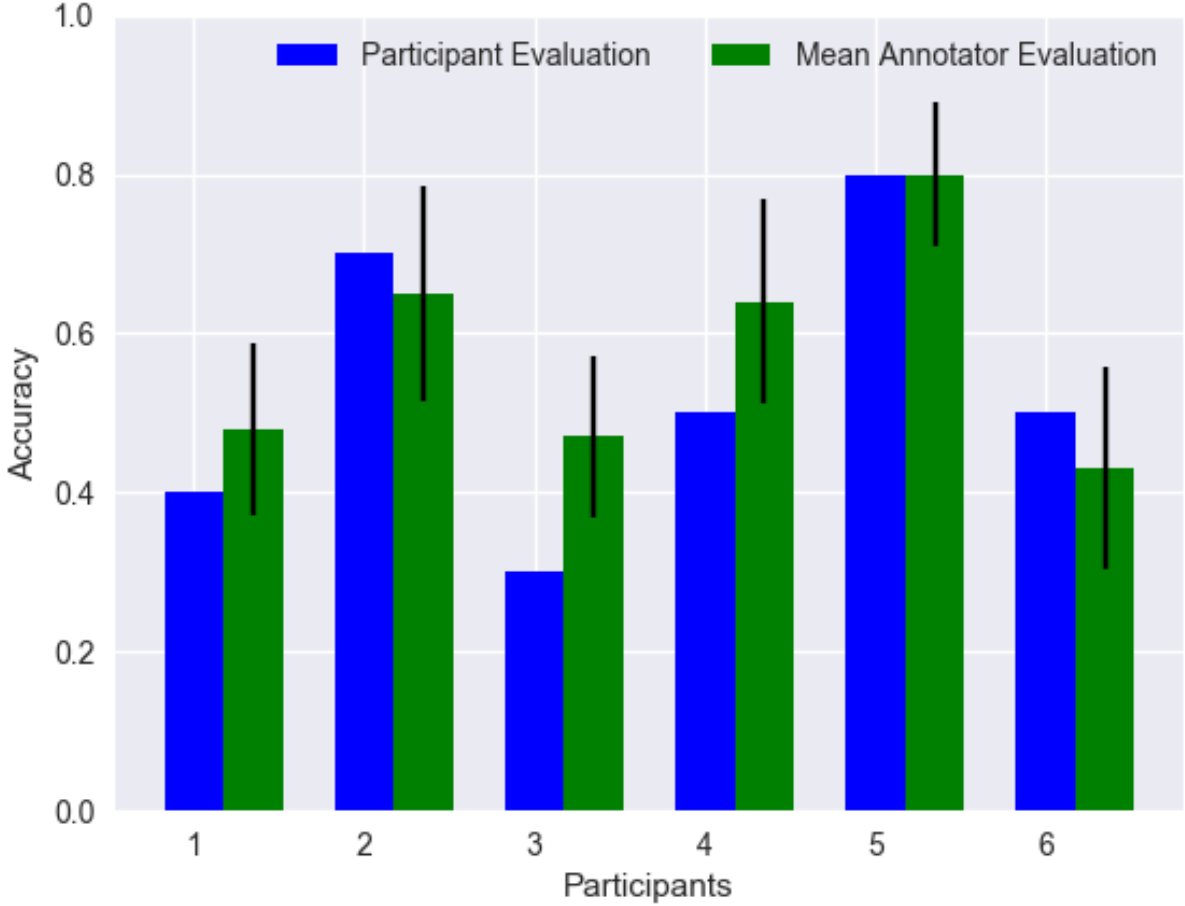
User Evaluates the Generated face for appropriateness. Based on the user evaluation, robot is rewarded.

Learning with Users: Results



Robot mood evolving over 10 interactions (each lasting for 5-6 seconds) for each participant. Area under the curves with different colors represent the fraction of neurons in the resultant mood of the robot for each corresponding emotion.

Learning with Users: Results



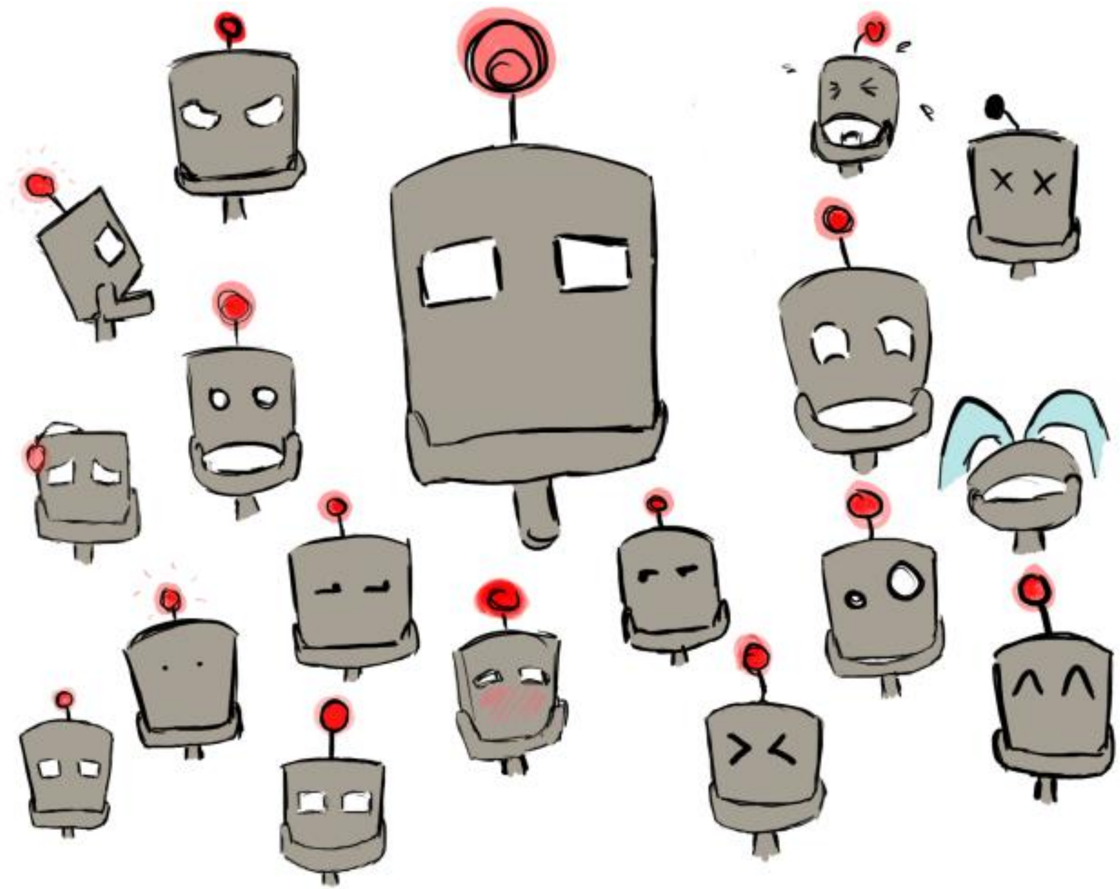
Participant and Mean Annotator Evaluations (κ = 0.51) on the appropriateness of the generated expression on NICO.

Conclusion

- A Deep Hybrid Neural Network is presented for emotional appraisal and expression generation.
- Empathy an important factor to learn robot behaviour.
- Emotion Classification is only half of the story.
- Intrinsic Emotional representations in the robot allow for better affective interactions with users.
- Spontaneous emotions along with affective contextual memory is important to model dynamic and fluid human-robot interaction.

- **Future Work:**
  - Learned actions can be enhanced to cover a richer continuous space dealing even with multiple modalities.
  - Using linguistic information to improve contextual understanding.

Q & A



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