Emotional Speech Recognition toward Modulating the Behavior of a Social Robot

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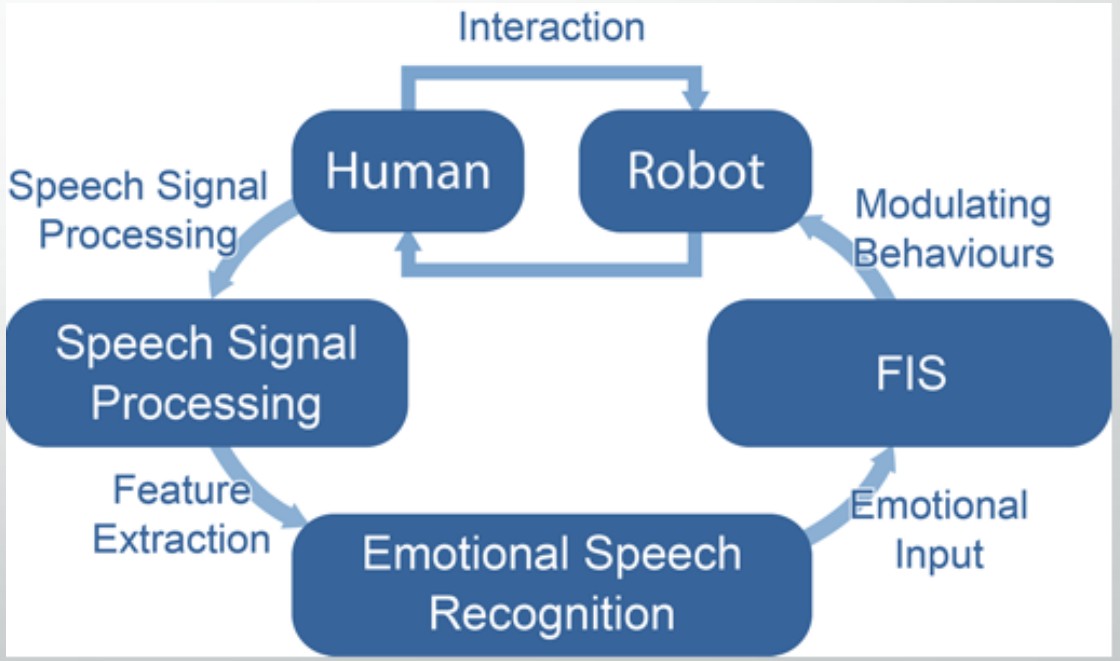
Social robots

- The incorporation of social robots in education, special treatment and therapy, requires that robots can interact socially with individuals.
- The effectiveness of human-robot interaction depends on the ability of the social robot to adapt its behaviour according to human emotional states.
- This work proposes a novel behaviour modulation system for social robots based on emotional speech recognition.

The Behaviour Modulation System (BeMoSys)

- The proposed methodology involves three stages:
  1. Feature extraction from the voice signal.
  2. Signal classification to various emotional states.
  3. Behaviour modulation.



Emotion Recognition

- The OpenVokaturi library was used for emotion recognition from the human voice.
- Validated with existing emotion databases.
- Predicts five emotions; happiness, sadness, anger, fear, and neutrality.
- Returns probability of each emotion being present in a given signal.
- The highest value among all predictions, determines the dominant emotion.
- Result: 66.5% accuracy.

Robot actions

- Three categories of robot actions:
  - Facial expressions (eye LEDs).
  - Sounds (audio tracks and music).
  - Animation (gestures and postures, using the robot's head, arms and legs).

Action category	Individual Behaviours
Facial expressions	• Eye LEDs (colours, blinking frequency)
Sounds	• Happy sounds • Relaxing sounds • Music
Gestures/Postures	• Head movements • Arm movements • Leg movements

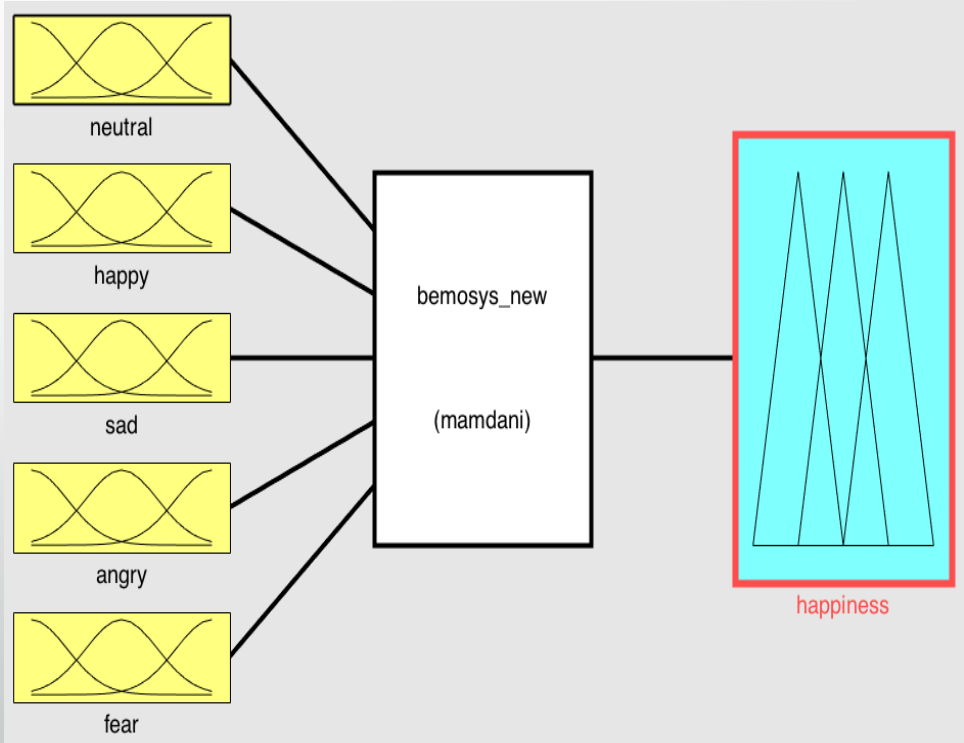
Robot behaviours

- Robot actions are combined and form the five pre-set distinct robot behaviours, A to E.
- Behaviour A is the robot's response to lowest levels of estimated happiness.
- Behaviour E is the robot's response to the highest levels of estimated happiness.

Behaviour	Description
A	Eye LEDs (colour set to white); Relaxing sound; Relaxing animation
B	Eye LEDs (blinking); Relaxing sound; Animation to attract attention
C	Eye LEDs (rapidly blinking); Cheerful sound; Zestful animation
D	Eye LEDs (rapidly alternating colours); Enthusiastic sound; Cheerful animation
E	Eye LEDs (rapidly alternating colours); Upbeat music; Enthusiastic animation

The Fuzzy Inference System (FIS)

- There are five inputs to the FIS which correspond to the five emotions extracted from the speech signal.
- The knowledge base of the inference system consists of 47 rules, which map the inputs to a single output value referring to the level of estimated happiness.
- Based on the value of estimated happiness, one of the five pre-defined robotic behaviours is selected.



Experiment (1)

- 399 speech recordings retrieved from the Berlin Database of Emotional Speech were used:
  - 74 recordings of neutrality.
  - 71 recordings of happiness.
  - 126 recordings of anger.
  - 67 recordings of fear.
  - 61 recordings of sadness.

Experiment (2)

- For each recording, the resulting emotional context of the speech signal was calculated and supplied to the FIS.
- The FIS calculated the estimated level of happiness.
- A robot behaviour was selected according to the estimated level of happiness.

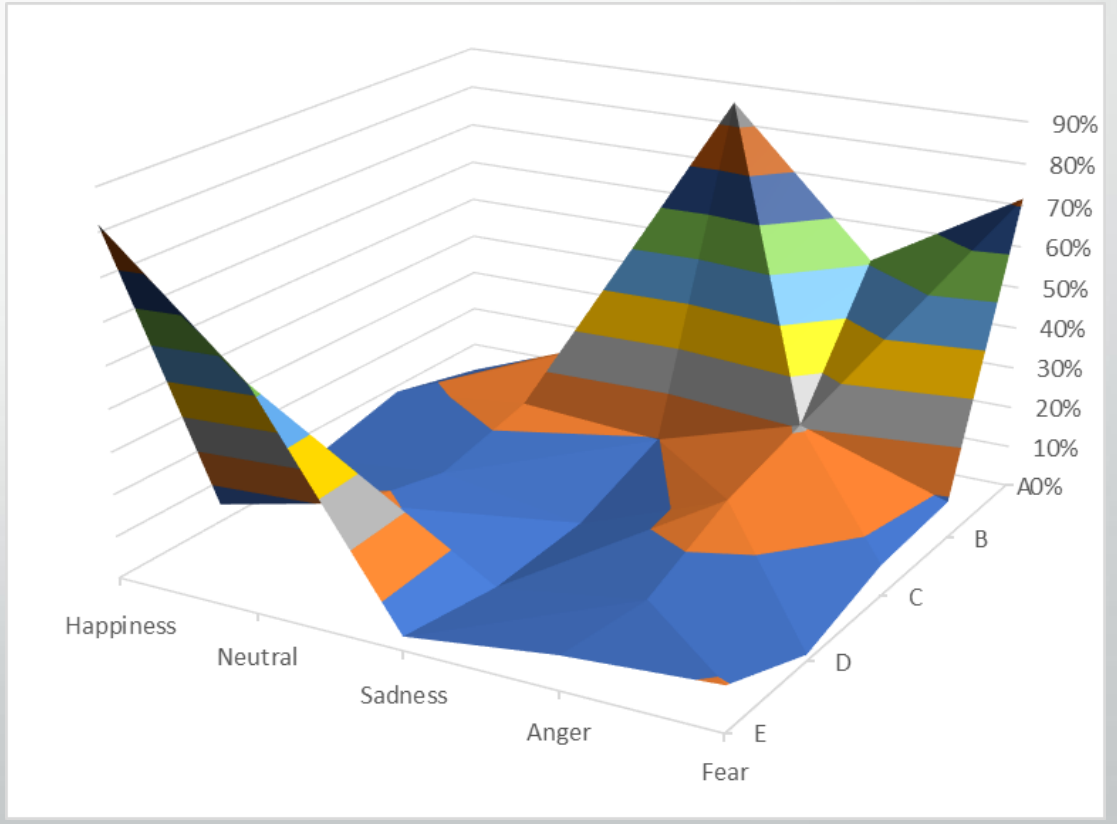
Results

- The BeMoSys was implemented on a NAO robot.
- Selection of an appropriate behaviour given an emotional speech signal is successful most of the times.
- Discrepancies are observed due to the limited accuracy of the emotion recognition library.

Behaviour / Emotions	A	B	C	D	E
Happiness	3%	8%	3%	4%	82%
Sadness	85%	10%	2%	0%	3%
Anger	51%	21%	15%	6%	7%
Fear	72%	9%	7%	2%	10%
Neutrality	16%	12%	7%	12%	53%

Selected behaviours based on calculated happiness level

- BeMoSys appears to be very consistent.
- When the detected emotion is anger, sadness or fear, then the system is driven to lower values of happiness level, and triggers the appropriate robot behaviours.
- Clearly happy emotional input, leads to the activation of reinforcing robot behaviours.



Conclusions

- A behaviour modulation system was implemented on the social robot NAO.
- The robot records the human voice and extracts the emotional content with the help of a well-known software application.
- Extracted emotions act as inputs to a FIS in order to map emotions to robotic actions.
- Future work will focus on applying the proposed system in the areas of special treatment and education.

Thank you

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