Deep Neural Networks for Detecting Real Emotions Using Biofeedback and Voice

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Introduction & Background

- Brain - Complex organ
  - Capable of controlling all functions in the human body
    - Also creates emotion
- Emotions - states related to physiological responses
  - appear due to external or internal stimuli
  - can be distinguished from each other via facial expressions, and behavioral responses,
    - most common: happiness, sadness, disgust, etc.
  - Changes in physiological signals are related to emotional states
    - Involuntary
    - people are often unaware of them.
- physiological signal analysis - reliable for emotion recognition.
  - automatic recognition of emotion has gained plenty of attention in recent years
    - still difficulties in getting machines to think or behave like humans
      - Especially for emotion recognition

Research Problem

- When in an interview, peoples' emotions change differently
  - beneficial to detect emotions in real-time
    - Why?
      - reduce incidences of embarrassing situations happening
      - Eliminate ambiguity caused by participant's Q & A (questions and answers)
      - Improve emotional comfort
- Successful emotional recognition needs relevant data
  - Collecting relevant data - still difficult
    - Different types of interviews
      - Interviews - most important content for investigators
        - Different forms of dialogue, themes of content, obvious changes in emotions
    - form of interviews -very difficult to control
      - errors can make the collection of experimental data meaningless.

Purpose of Study

- help investigators and participants reduce inconsistency and ambiguity of the interview content
- Introduce new solution for detecting emotion
  - Biofeedback
    - not many research uses biofeedback in order to detect emotion
- Goal: build a model that can predict emotions based on biometric inputs.

Literature Review

- Previous solutions used images or videos
- Current methods used to solve emotion detection problems:
  - classification algorithms and deep learning algorithms
    - support vector machines (SVM)
    - Naive Bayes (NB)
    - K-nearest neighbor (KNN)
    - multilayer perceptron (MLP)
    - long-short-term-memory (LSTM)
    - convolutional neural network (CNN)
- Albraikan, A., et al. proposed real-time mobile biofeedback system
  - Called iAware
    - Depicts five basic emotions and provides the user with emotional feedback
    - Results: successful
      - iAware increased emotional self-awareness by reducing the predictive error by 3.333% for women and 16.673% for men

Methods / Experimental Design

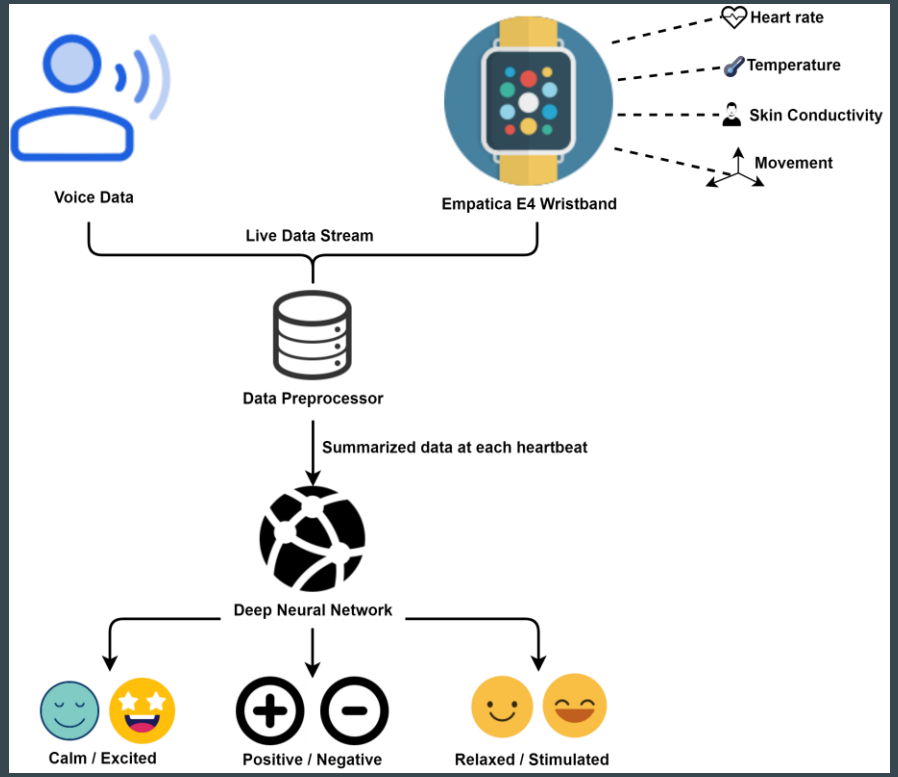


Fig. 1: The model shows the deep neural network processing data from the E4 wristband and the voice recordings in order to achieve the emotional ranges.

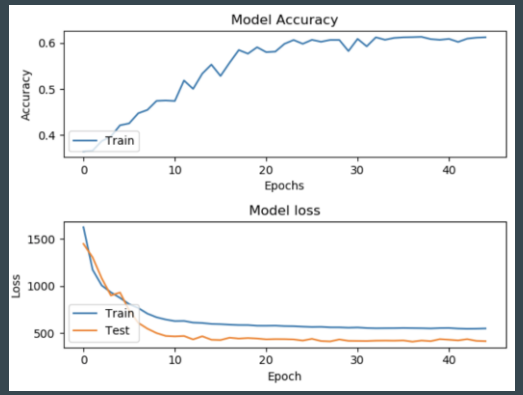
- Involved Empatica E4 wristband
  - can record people's different feedback and reactions to emotions in real-time
- Experiment needed to answer 2 questions:
  - (1) Which technology in machine learning is the most effective and can bring the greatest development to this experiment?
  - (2) What kind of function in machine learning can be maximized in the experiment?
- Used Deep-ANN (Deep Artificial Neural Network)

- To build Deep-ANN:
  - Used TensorFlow and Keras libraries
  - Python Version used: Version 3.6
- Data was stored in CSV file
  - 19 features, 3 output labels
    - After removing data with missing labels: had over 10,000 rows from our original dataset
- Data normalization: done via MinMax scaling
- Used NumPy: store data into feature and label matrices
  - Shape: M x 19 and a y label matrix of M x 3
    - M = number of data points
- used a feed-forward deep neural network
  - Epochs: set to 45
- Data split: 80% Training 20% Testing
- Loss function(s) used: mean squared error(MSE) and mean absolute error (MAE)
- Optimizer used: Adam

Results / Research Findings

- Results of proposed model:
  - training loss is 4.5009
  - training accuracy is 1.0000
  - testing loss is 4.5515
  - testing accuracy is 0.8511
- After improvements for Deep ANN:
  - accuracy of 85%(testing set) and 79% (validation sets) was consistently achieved
- Loss function - effected results the most
  - MSE - gave more consistent accurate results
  - Best results: achieved by Leaky ReLu function

(a)



(b)

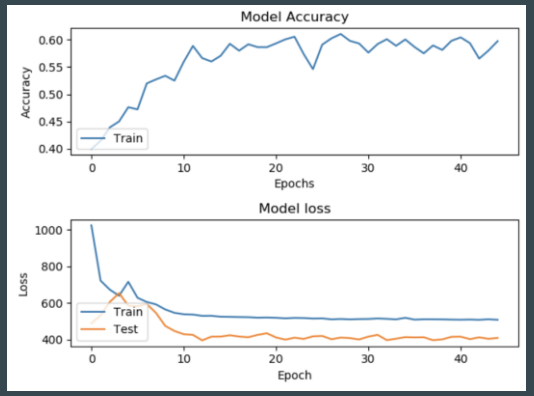
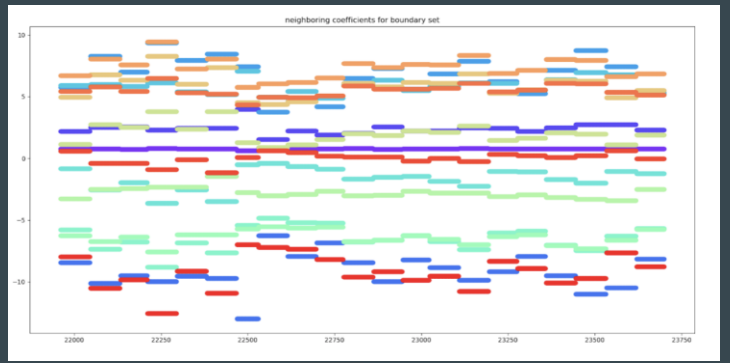


Fig. 2: Multimodal emotion recognition using variety of advanced hyperparameters.
(a) Model using mean squared error loss function; (b) Model using Nadam; (c) Model using adamax.



(c)

Summary

- When in an interview people's emotions will change differently depending on factors such as questions asked.
- So, It is beneficial detect people's emotions in real-time.
  - However: Difficult to collect required data
    - Solution
      - Combine usage of Empatica E4 wristband with machine learning to help convey participants' emotional ranges.
        - Via Deep ANN
- Deep ANN achieved stellar results with 85% accuracy in our testing set and 79% in validation sets to determine the emotional scale.

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