Affective Computing Patents

ARI FRANK, PH.D. AND GIL THIEBERGER

SEP 10, 2015

Affective Computing Patent Batch

- All patents and pending applications include broad claims relating to affective computing
- All have priority date May 11, 2011, and filing date June 25, 2011.
- 7 Granted US Patents:
  - 8863619 – Methods for training saturation-compensating predictors of affective response to stimuli
  - 8886581 – Affective response predictor for a stream of stimuli
  - 8898091 – Computing situation-dependent affective response baseline levels utilizing a database storing affective responses
  - 8918344 - Habituation-compensated library of affective response
  - 8938403 – Computing token-dependent affective response baseline levels utilizing a database storing affective responses
  - 8965822 – Discovering and classifying situations that influence affective response
  - 9076108 - Methods for discovering and classifying situations that influence affective response
- 2 allowed US applications
  - 13/168962 - Situation-dependent libraries of affective response
  - 13/168960 - Database of affective response and attention levels

The Concept: Going Beyond Health – Affective Computing

- Currently physiological sensors (e.g., Apple Watch, Samsung Simband) are used primarily for health tracking
- Various signals are already being collected:
  - **On Simband**: Electrocardiogram (ECG), bio-impedance, (bio-z), photoplethysmogram (PPG), galvanic skin response (GSR), accelerometer, and skin temperature
  - **Other signals** may collected through other means such as electroencephalogram (EEG) or facial expressions (using cameras), and other signals can also be used to determine emotional response
- Even just the signals collected by Simband are enough to determine emotional response
  - To what extent the user feels: Happiness, Sadness, Surprise, Fear, Disgust, or Anger (Ekman '72)
  - Mapping a user's emotion to a Valence/Arousal parameter space

Affective Computing Applications

- Affective computing involves applications where a computer measures the emotional response of the user and incorporates this information into services provided to the user

Examples include:

- Learning user preferences from emotional response
  - Suggesting content the user will like (movies, music, games)
  - Presenting advertisements to which a user will react
- Adapting content based on emotional response:
  - changing difficulty of a game to keep a user engaged
  - making a horror movie more scary if needed
  - having a robot react to emotional response of a user

Current Affective Computing Limitations

Most current affective computing applications are simplistic:

- Typically relate to **whole segments** of content (a game level, a song, a video).
- Do not relate to individual aspects of content or environmental conditions
- Do not identify or relate to the situation of the user (e.g., is the user alone or in a crowd, at home or at work, etc.)
- Do not take into account phenomena such as **habituation** (reduced response after repeated exposure to the same stimulus) or **saturation** which is reduced response when given many stimuli (sensory overload)
- Do not compare the affective response of the user to a suitable baseline (e.g., a baseline that corresponds to the situation the user is in)

- **Our patents address above shortcomings and cover a wide range of aspects needed for successful real-world affective computing**

Patented Elements - Tokens

- Affective response is modeled as being dependent on tokens to which a user is exposed; Tokens can be many things, some examples include:
  - Objects / products (cars, clothing items, foods, gadgets)
  - Characters (people, animated characters, celebrities)
  - Music, sound effects, visual effects
  - Low level features: values corresponding to brightness, color scheme, rhythm, odor, etc.
  - High level features: values describing concepts like brands, genres, quality, media type, etc.
  - Environmental conditions: temperature, humidity, allergens, noise level, etc.
- A user may be simultaneously exposed to multiple tokens (e.g., two characters appearing together in a movie scene)
- A user may be exposed to tokens coming from multiple sources (a game, the environment, another user, etc.)

Patented Elements - Situations

- A situation of a user describes a factor of a mental state that can influence the emotional response
  - Social conditions - is the user alone or in a group? with a spouse or a stranger?
  - Location – is the user at home, at a friend's house, or at work?
  - State of mind – being late to a meeting, in financial trouble, just received a bonus
  - Physiological state/mood – sick, tired, hungry, alert, rested

- Depending on the situation a user is in, the affective response of the user can be significantly different
  - e.g., a user may have different response to adult-themed material when alone compared to when with company

- Accounting for the situation can improve accuracy of various components such as predictors, libraries, and baselines

Patented Elements - Baselines

- A baseline is a typical level of a measurement of affective response (e.g., heart rate, skin conductance, etc.)
- When determining emotional response it can be beneficial to compare a measurement to a baseline in order to determine the difference
- A baseline can be measured (e.g., during a window of previous minutes or hours)
- A baseline can be predicted (e.g., based on previous measurements stored in a database)
- More accurate baselines can be created if additional factors are taken into account, such as the situation the user is in and/or the type of tokens to which the user is exposed

Patented Elements - Predictors

- A predictor is a machine learning-trained model that receives tokens to which a user was exposed during a certain period (window), and returns a predicted emotional response of the user to the tokens
  - Various machine learning approaches may be used: regression models, neural networks, support vector machines, decision trees, etc.
- A predictor may take into account additional aspects
  - Number of pervious exposures – to account for habituation
  - Total weight of tokens the user is exposed to – to account for saturation (sensory overload)
  - A situation the user is in when exposed to tokens

Patented Elements - Libraries

- A library is a database of affective response to individual tokens
  - Can be used to select elements to present to a user (e.g., does the user prefer Toyota or Kia?)
  - Can be used to select elements to which the user is expected to have a positive emotional response
- A library is derived from a machine learning-trained model of a predictor
  - Weights of regression parameters corresponding to a token
  - Weights on nodes corresponding to a token in a decision tree
- The same token may have different associated affective responses under different conditions
  - A library in which the response to a token depends on the situation the user is in
  - A library in which the response to a token depends on the number of exposures of a user to the tokens (to compensate for habituation)

Limitations of Our Technology

- Advance affective computing applications require detailed information (e.g., descriptions of tokens and situations)
  - Identifying tokens may require vision algorithms that can identify people, objects and other algorithms for detecting and understanding environmental conditions
  - Situations may also need to be identified using various forms of analysis (e.g., semantic analysis of communications, advanced perception of social interactions)
- However, identifying tokens can be done automatically in some cases such when involving digital content (e.g., tokens can be provided by a computer game, a virtual world, an augmented reality interface)
- As recording and analyzing day-to-day experiences becomes more prevalent (e.g., life-logging and agent technologies), the capability to extract tokens and situations should increase significantly

US 8863619 - Predictor (Saturation)

Title: Methods for training saturation-compensating predictors of affective response to stimuli

- Trains a predictor of emotional response from samples that describe tokens to which a user is exposed
- The predictor takes into consideration the non-linear effects that being exposed to multiple tokens has on a user
  - when a user is exposed to many tokens, each token may have a smaller effect on the affective response of the user, compared to a case where the user is exposed to only a few tokens
- **Advantage**: more realistic and accurate predictions since the predictor takes into account the effects of saturation (sensory overload)

US 8886581 – Predictor (Stream)

Title: Affective response predictor for a stream of stimuli

- The stream of stimuli is partition into windows comprising tokens (e.g., each window can correspond to a commercial, a level in a game, a scene in a movie, a page on a website)
- The predictor predicts affective response to each window by using the output of the previous window as an initial state for the prediction of the current window
- **Advantage:** More accurate prediction for a large amount of stimuli
  - The predictor can break the stream into more manageable chunks of data (windows)
  - The predictor maintains continuity in predictions by using the prediction of each window as a starting point for the prediction of the next

US 8898091 – Baseline (Situation-based)

Title: Computing situation-dependent affective response baseline levels utilizing a database storing affective responses

- A user's affective response to stimuli is typically a temporary departure from a steady baseline affective state
- The baseline state of a user depends on the situation the user is in (alone or in a group, at home or at work, sick/tired/just got up, etc.)
- This invention involves computing a baseline value for a user in a specific situation from previous measurements of the user when he/she was in the specific situation (and not necessarily measurements taken directly before the current stimuli are presented)
- **Advantage:** A more accurate computation of baseline for a specific situation
  - enables a better determination of the affective response when the user is in the specific situation (since we have a better idea of what the "regular" baseline measurement values should be in the specific situation)
  - Disregarding the situation when determining a baseline leads to less accurate emotional response predictions

US 8938403 – Baseline (token-based)

Title: Computing token-dependent affective response baseline levels utilizing a database storing affective responses

- A user's baseline may depend on the type of tokens to which the user is exposed
- A baseline for a user being exposed to a window of token instances (e.g., a commercial, a video clip, game level, visit in a real or virtual room) is computed from measurements when the user was exposed to similar tokens
  - This can enable generation of specific baseline such as a baseline for car commercials, beer commercials, shooter video game, baseline for browsing Facebook, baseline for listening to Rock music
- **Advantage:** Having a token-dependent baseline gives a better idea of what the typical reaction of the user is to certain content. This enables a more accurate determination of the emotional response of the user to a new segment of similar content.

US 8965822 – Situation Discovery (systems)

Title: Discovering and classifying situations that influence affective response

- Systems that can learn to identify situations a user is in, based on measurements of affective response corresponding to windows of tokens to which the user is exposed (in the real world)
- Utilizes various machine learning approaches:
  - **Clustering (unsupervised)-** identifies clusters of samples corresponding to situations by using a distance function that takes into account both similarities of tokens and measured affective responses
  - **Expectation Maximization (EM – semi-supervised)** – trains a model for identifying situations where many of the samples may not have an identified situation
  - **Classification (supervised)** – Training a classifier with samples that have situation labels
- **Advantage:** Diverse systems for discovering situations, including systems that need minimal human intervention; enables adding situation identifiers to the process of predicting emotional response to obtain more accurate predictions

US 9076108 – Situation Discovery (methods)

Title: Methods for discovering and classifying situations that influence affective response

- **Corresponding method claims to system claims in US 8968522**
- Utilizes various machine learning approaches:
  - **Clustering (unsupervised)-** identifies clusters of samples corresponding to situations by using a distance function that takes into account both similarities of tokens and measured affective responses
  - **Expectation Maximization (EM – semi-supervised)** – trains a model for identifying situations where many of the samples may not have an identified situation
  - **Classification (supervised)** – Training a classifier with samples that have situation labels
- **Advantage:** Diverse method for discovering situations, including systems that need minimal human intervention; enables adding situation identifiers to the process of predicting emotional response to obtain more accurate predictions

US 8918344 – Library (Habituation)

Title: Habituation-compensated library of affective response

- Library of affective responses to tokens is derived from a machine learning predictor
  - Predictor may be regression model, neural network, maximum entropy classifier
  - Predictor takes into account information about **how many times the user was exposed to tokens**
- Library includes for same tokens different responses based on number of previous exposures to token (e.g., a response to initial exposure, after ten exposures, etc.)
- **Advantage:** Response to tokens may change significantly based on the number of exposures to tokens (e.g., a user may get bored with tokens of a certain commercial after repeated exposures). This Library can reflect these effects and thus is a more accurate representation of affective response to tokens

Pending US app 13/168962 Library (Allowed)

Title: Situation-dependent libraries of affective response

- Library of affective responses to tokens is derived from a machine learning predictor
  - Predictor may be regression model, neural network, maximum entropy classifier
  - Predictor takes into account information about **the situation the user was in** when exposed to tokens
- Library includes for same tokens different responses based on what situation the user was in (e.g., there may be a different response to the same token when the user is alone or in a group)
- **Advantage:** A user may have very different responses to the same tokens when in different situations (e.g., tired, worried, sick, in relationship, etc.) This Library can reflect these effects and thus offers a much more accurate representation of affective response to tokens

Pending US app 13/168960 (Allowed)

Title: Database of affective response and attention levels

- Claims for memory, machine, and computer medium that store a database
- Database has novel feature that it stores (and links between) tokens, a measurement of affective response of a user (to the tokens), the situation the user was in at the time, and the attention the user was paying to the tokens
- **Advantage:** Advanced affective computing applications can utilize various sources of data to learn and predict emotional response. These include what the user was exposed to (tokens), the user's state (situation), what the user was focused on (attention), and the affective response (measurement). This database stores and links between all this information thus enabling algorithms to access all these different sources of information

Thank you for listening!