Power Saving Patents

ARI FRANK, PH.D. AND GIL THIEBERGER

SENT TO SYNPAT CORP

SEP 10, 2015

Power Saving Patent Batch

- All patents and pending applications include broad claims related to saving power when operating sensors that take measurements of affective response
- Priority date October 14, 2012
- 6 Granted US Patents:
  - **8898344** – Utilizing semantic analysis to determine how to measure affective response
  - **9058200** – Reducing computational load of processing measurements of affective response
  - **9032110** – Reducing power consumption of sensor by overriding instructions to measure
  - **9086884** - Utilizing analysis of content to reduce power consumption of a sensor that measures affective response to the content
  - **9104969** Utilizing semantic analysis to determine how to process measurements of affective response
  - **9104467** - Utilizing eye tracking to reduce power consumption involved in measuring affective response
- One Pending US application
  - **14/791304 (should be allowed soon)** - Reducing power consumption of a wearable device utilizing eye tracking

Affective Computing is the Killer App for Wearables

- Wearables, like the Apple watch, seemed to be lacking a killer app, and are thus maybe receiving a lukewarm reception in the market
- We believe that affective computing is the killer app for wearables
- But using wearables for affective computing may further accentuate their issues regarding power consumption
- The technology described in our patents makes it possible to significantly conserve power when using wearables for affective computing applications

Affective Computing – Going Beyond Health

- Sensors in mobile devices and wearables are used primarily for health tracking
- Some of the signals that are collected via various sensors:
  - Electrocardiogram (ECG), photoplethysmogram (PPG), galvanic skin response (GSR), skin temperature, electroencephalogram (EEG), cameras (e.g., for facial expressions), and accelerometers (for movement)
- Even just a subset of those signals is enough to determine emotional response
  - Extent of each core emotion: Happiness, Sadness, Surprise, Fear, Disgust, or Anger
  - Mapping a user’s emotion to a Valence/Arousal parameter space

Affective Computing Applications

- Affective computing involves applications in which a computer measures the emotional response of a user in order to improve 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 positively
- Adapting content and behavior 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

The Problem

- Measuring affective response is power consuming
  - Apple watch measures the user every ten minutes
  - When the measuring rate increases to a few times a minute (e.g., while exercising), the battery is drained significantly
- Affective response of a user can be measured to **hundreds** and even **thousands** of segments of content during a day
  - Commercials, Twits on twitter, posts on Facebook, games, songs, music videos, SMS messages, WhatsApp conversations, phone conversations,…
- Measuring affective response to everything will severely drain batteries
  - **Devices will not have enough battery power to get through the day!**

Our Solution

- Don’t measure affective response to thousands of segments of content
  - Only measure affective response when the response is likely to be interesting
  - Interesting response = response that exceeds a threshold
- Evaluate content to determine whether response is expected to be interesting
  - If it is not expected to be interesting, measure/process using less power or don’t measure at all
- Being selective about when to measure can drastically reduce the power consumed for measuring affective response
  - Maximize the utility (measure when response is interesting)
  - Minimize the risk of not measuring interesting responses

Analysis of Content to Determine Affective Response

- Content presented to a user is analyzed to determine whether the user is expected to have a significant emotional response
  - If predicted emotional response reaches a threshold – measure/process at a first level
  - If predicted emotional response does not reach the threshold – measure/process at second level
- **The second level consumes less power than the first**
  - Fewer measurements are taken in the second level (or none at all)
  - Less advanced processing in the second level
  - Less data is transmitted in the second level (or none at all)
- The decision on how the user should be measured may be done before the content is presented in order to get a full measurement and/or baseline prior to exposure to content

Analysis of Content (general/semantic)

- Content may be analyzed **before** it is presented to the user
- **A content ERA (Emotional Response Analyzer)** utilizes a machine-learning predictor
  - Receives tokens derived from the content and predicts emotional response
  - Predicts things like is the user going to be scared by a video clip? Is the user going to be disappointed by what is about to happen in a game the user is playing? Is the user going to be excited by an SMS the user is about to read?
- **A semantic analyzer** utilizes semantic analysis of content to predict emotional response
  - Lexicon that associates words and/or phrases with their core emotions
  - Latent Semantic Analysis (LSA) - statistically analyzing the frequency of words and/or phrases in the text in order to associate the text with certain likely concepts and/or categories
  - Algorithms for determining emotion expressed in text

Limitations of Our Technology

- A content ERA utilizes a machine-learning based predictor
- Requires features that describe the content, objects in the real world, and/or situations a user may be in
  - Generating the features may require AI with some understanding of the world
  - Advancements in agent technology may help (e.g., IBM Watson, Apple Siri, etc.)
  - A digital content source (e.g., computer game, virtual world) may provide needed feature values automatically

US 8898344 - Reduce Measuring Rate

Title: Utilizing semantic analysis to determine how to measure affective response

- Semantic analyzer receives a segment of content that represents text and performs semantic analysis of the text
  - Determines whether the user is going to have a significant emotional response
- Based on results of semantic analysis, a controller determines the rate at which to measure affective response of a user with a sensor
  - A “power saving rate” takes at least 50% fewer measurements
    e.g., different sensor settings such as voltage, resolution, and/or sampling rate
  - A “power saving rate” may involve not measuring the user at all!
- **Advantage:** The system decides to what extent to measure a user based on the content to which the user is exposed; thus if the content is not expected to evoke an emotional response, the user may be measured to a lesser extent. **This saves power!**

US 9104969 - Using Semantic Analysis to Reduce Computational Load

Title: Utilizing semantic analysis to determine how to process measurements of affective response

- Semantic analyzer receives a segment of content that represents text and performs semantic analysis of the text
  - Determines whether the user is going to have a significant emotional response
- Based on results of the predictions, a processor processes affective response data acquired with a sensor at different levels
  - A "power saving rate" performs at least 50% less computations on a certain volume of data (e.g., use less computational intensive procedures)
- If there is no expected "interesting" emotional response,
  - no need to perform extensive filtering and/or pattern recognition
  - no need to transmit measurements to an external server
- **Advantage:** The system may decide to what extent to process data from sensors based on the content to which the user is exposed; thus if the content is not expected to evoke an emotional response, the data is not processed extensively (or transmitted). **This saves power!**

US 9086884 – Reduce Power Consumption of Sensors

Title: Utilizing analysis of content to reduce power consumption of a sensor that measures affective response to the content

- A content ERA predicts emotional response to a segment of content
  - Can utilize a machine-learning based predictor
- Based on results of the prediction, a controller selects a mode of operation at which to operate a sensor that measures the user
  - Mode of operation may control parameters such as voltage and/or sampling rate
  - A "power saving mode of operation" consumes 50% less power to operate the sensor
  - A "power saving mode of operation" may involve not measuring the user at all!
- **Advantage:** The system decides to what extent to measure a user based on the content to which the user is exposed; thus if the content is not expected to evoke an emotional response, the user may be measured using less power (or not measured at all). **This saves power!**

US 9058200 – Reduce Computational Load

Title: Reducing computational load of processing measurements of affective response

- A content ERA receives a segment of content and predicts emotional response to it
  - Can utilize a machine-learning based predictor
- Based on the result of the prediction, a processor processes affective response data acquired with a sensor at different levels
  - A "power saving level" performs at least 50% less computations on a certain volume of data (e.g., use less computational intensive procedures)
- When there is no expected "interesting" emotional response
  - no need to perform extensive filtering and/or pattern recognition for EEG data
  - no need to process light field images of the user's face
- **Advantage:** A system may decide to what extent to process data from sensors based on the content to which the user is exposed; thus if the content is not expected to evoke an emotional response, the data is not processed extensively (or transmitted). **This saves power!**

US 9032110 – Overriding Instructions to Measure (tags)

Title: Reducing power consumption of sensor by overriding instructions to measure

- Tags indicate when to measure a user affective response with a sensor
- A measurement from a first sensor (e.g., camera) is used to determine whether a threshold is reached (e.g., whether the user is paying attention)
- Depending on whether the threshold is reached, a controller determines the level at which to measure affective response of a user with a second sensor (e.g., Apple watch, EEG)
  - A “power saving level” is used when the threshold is not reached
  - In this mode, the second sensor consumes at least 50% less power (or none at all)
- **Advantage:** A system may decide to ignore instructions to measure if the measurements are not likely to be meaningful. For example, if the user is not looking at a screen there is no reason to measure the user’s response to elements on the screen. **This saves power!**

US app 9104467 - Override Instructions to Measure Based On Eye Tracking

Title: Utilizing eye tracking to reduce power consumption involved in measuring affective response

- Tags indicate when to measure a user affective response with a sensor
- Eye tracking is used to determine whether a user is paying attention to content
- Depending on whether an attention threshold is reached, a controller determines the level at which to measure affective response of the user with a second sensor (e.g., Apple Watch, Samsung Simband, EEG)
  - A "power saving level" is used when the threshold is not reached
  - In this mode, the second sensor consumes at least 50% less power (or none at all)
- **Advantage:** A system may decide to ignore instructions to measure if the sensor measurements are not likely to be meaningful. For example, if the user is not looking at a screen there is no reason to measure the user's response to elements on the screen. **This saves power!**

US 14/791304 (should be allowed soon) - Reducing power consumption of a wearable device utilizing eye tracking

Title: Reducing power consumption of a wearable device utilizing eye tracking

- Eye tracking is used to determine whether a user is paying attention to content
- Depending on whether an attention threshold is reached, a controller determines the level at which to measure affective response of the user with a second sensor (e.g., Apple Watch, Samsung Simband, EEG)
  - A “power saving level” is used when the threshold is not reached
  - In this mode, the second sensor consumes at least 50% less power (or none at all)
- **Advantage:** A system may decide not to measure with a sensor if the sensor measurements are not likely to be meaningful. For example, if the user is not looking at a screen there is no reason to measure the user’s response to elements on the screen. **This saves power!**

Thank you for listening!