Mindful: A Platform for Large-Scale Affective Field Research

Guy Feigenblat, Jonathan Herzig, Michal Shmueli-Scheuer, David Konopnicki
IBM Haifa Research Lab
Haifa 31905, Israel
{guyf,hjon,shmueli,davidko}@il.ibm.com

ABSTRACT

In this work we present *Mindful*, a platform for defining, configuring, executing and distributing affective experiments to a large scale audience. This type of experiments measure the emotional reaction of participants to media content selected by experimenters. Furthermore, the platform manages profiles of registered users who have agreed to participate in an experiment as well as a data collection and analysis mechanisms. The analyzed data is then used to enrich users' profile and to better understand their emotional behavior. Throughout the paper we describe the platform in details and present a use case of how the platform is being used in practice.

1. INTRODUCTION

The affective computing research domain, pioneered by Rosalind Picard more than ten years ago in [9, 10], is widely explored by psychologists, sociologists, and computer scientists and encompasses many fascinating fields of study. Among them are exploring the means of sensing and recording emotions, cognitive modeling, emotions expression by agents and more. In practice, many researchers that wish to run experiments in this fields encounter the same fundamental technical obstacles in the process of gathering, measuring and analyzing data. Namely, as in many quantitative research, in the affective domain, researchers would like to work on large scale research, which, in practice, means recruiting many participants. This is not achieved easily: it requires finding a target audience matching the research profile and on the willingness of members of the audience to participate. Then, it is often necessary to bring the participants to a lab in order to execute the experiment. Moreover, even if the researcher has succeeded in recruiting many participants and bringing them to a lab, the manual data measuring and analysis phases are error-prone and tedious.

These are the obstacles we address through the platform for large scale affective field research we are currently building in this work. The platform offers a complete affective experiment design tool and data collection and analysis mechanisms for researchers who do not necessarily have an extensive technical skills. The designed experiments measure the emotional response of participants to media content selected by the experimenter. The main challenges that should be taken into account when designing such a platform are:

Experimental scale - the platform has to be able to cope with large data sets and support many users. **Configurability** - the platform must provide an easy interface, as many researchers do not have an extensive technology background. **Experiment distribution** - the platform should assist researchers in managing the candidates recruitment process and allow experiments to be performed remotely. **Cross platform** - the platform must support various client side operating systems. **Contextualization** - context data such as location, date, time etc. must be gathered and enrich the collected data and user profiles of the participants.

Mindful addresses all the aforementioned challenges: we have defined a general platform for defining, configuring, executing and distributing affective experiments to a large scale audience. To the best of our knowledge such a generic and comprehensive system was not described before.

The rest of the paper is organized as follows. In section 2 we survey some of the related work of this field, In section 3 we describe the platform in details, and in section 4 we describe a specific use case of the platform. Finally, we conclude and explore future work in section 5.

2. RELATED WORK

In this section we survey existing platforms for analyzing affects under various settings.

The works in [14, 13] suggest frameworks for interpretation of affective signals. Specifically, in SSI [14] the focus is real-time recognition of affective signals by supporting diverse input modes (e.g., web cameras, Nintendo's Wii, Kinect, Nexus, and more) in a coherent way. In addition, the authors provide some machine learning and pattern recognition tools. The CEED [13] utilizes the SSI platform for empathetic data experiments, and augments it by adding affects visualization. The primary focus of these works is on seamless interaction with new sensors through their APIs, and on analysis using machine learning libraries.

Other platforms leverage smartphones in order to understand user's emotions through phone interaction patterns, as well as phone sensors [11, 8]. EmotionSense [11] is a mobile based platform performing audio-based emotion recognition. The platform monitors emotions based on speech signals, as well as activities (e.g., moving vs. static), and then cor-

ImmersiveMe'14, November 7, 2014, Orlando, FL, USA.

http://dx.doi.org/10.1145/2660579.2660583.

relates between them. In addition, the authors allow the experimenter to define rules (using first order logic) to modify the sensors operations. MoodScope [8] predicts emotions of the users based on smartphone usage (e.g., apps usage, phone calls, SMS activities, and more). Those systems are quite different from ours; First, they do not provide any tools to define and to manage experiments. Second, types of data that they consider as emotional triggers are different. Finally, our system is not limited to mobile environment, while theirs is mobile by definition.

The Siento platform [2] aims at collecting data from physiological sensors, webcams and screen camera together with user interactions. The main difference between our platform and Siento is in the flexibility, and expressiveness that our system allows, including, the management of the users profile, the experiment management and the large scale distribution.

In addition, there exist industrial solutions such as nViso[1], and iMotions[2]. nViso integrates online questionnaires, and runs on different platforms. However, it is limited only to facial expressions analysis. The iMotions platform supports multi-sensors, as well as surveys and reports. However, to our understanding their system lacks of experiment's configuration and distribution capabilities as well as participants management.

3. PLATFORM

Mindful is designed in a traditional client-server architecture, in which the *client side* is a mobile application or a web browser (running either on a personal computer or a smartphone) that communicates with an application server on the *server side*. After a participant to an experiments has been selected, the client application retrieves information from the server related to the ongoing experiment. Due to the variety of smartphones and operating systems, one of the main requirements of the platform is to be independent from a particular client-side technology. To achieve that within our design, the logic executed on the client side is quite basic and its main responsibility is interaction with users and visualization. On the other hand, the server is responsible for maintaining the definition and configuration of experiments, assigning users to experiments, maintaining user profile, allowing the definition of experiments using a web user interface, analyzing results and more. After the definition of an experiment on the server, the client's main role is to retrieve instructions on how to conduct the experiment, interpret these instructions, create screens based on the server instructions and, upon experiment completion, uploading data to the server.

The data being uploaded to the server upon experiment completion is composed of two parts. The first part is composed from the response of the user to the questions asked during the experiment. The second part is the behavioral and affective data being collected through sensors while the user is exposed to the media content associated with an experiment.

Figure 1 depicts the high level architecture of the platform. In the rest of this section, we describe the significant platform components and some of the main client-server flows.

[1]http://www.nviso.ch/

[2]http://imotionsglobal.com

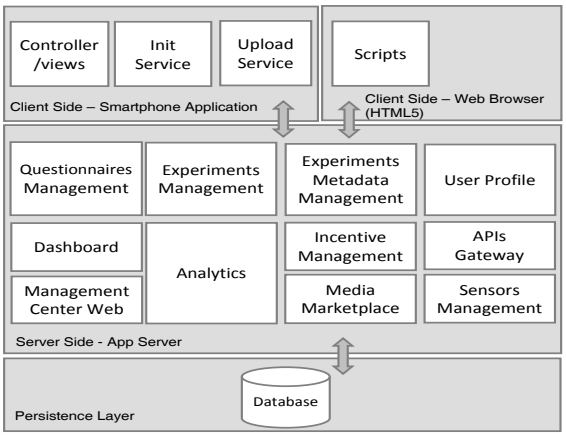

Figure 1: Server side blocks diagram

3.1 Questionnaires Management

An experiment is typically composed of several questionnaires to be filled by participants and this server module aims to facilitate their definition and configuration. To do so, the experimenter has to select or define the questionnaires being used. The platform offers two options: first, it is possible to choose from a set of pre-defined questionnaires that are part of the system. These are questionnaires commonly used in psychological and affective experiments, for instance the personality traits questionnaires [7], demographics [3, 12], emotional reaction to media content questionnaires [1, 15, 9] and more. Alternatively, the experimenter has the option to define new questionnaires using a web interface wizard. These questionnaires are encoded in an XML format and persisted to the system database upon wizard completion.

3.2 Media Marketplace Management

The main objective of the platform is to measure users' emotional response to media content. To accommodate that, this module manages a marketplace of video clips, audio segments, texts, and images to be selected by the experimenter for particular experiments.

A web user interface offers a convenient way to upload media and to share media with users participating in the experiments.

3.3 Experiments Metadata Management

Affective experiments are usually composed of two type of intertwined steps [9] that constitute the experiment flow: in each of those steps, a participant may be asked to answer questionnaires or a participant may be exposed to media content while its emotional reaction is being measured (typically using client side sensors, e.g., camera, microphone, wearables). This module assists experimenter in the process of defining a complete experiment flow by utilizing the *Questionnaires module* and the *Media Marketplace*.

As an illustrative example consider the following flow. The experiment is composed of three steps, in the first step, users are asked to answer a demographic questionnaire, then in the second step participants are asked to answer a personality traits questionnaire and finally in the third step participants are exposed to media content while sensors collect data.

To define this experiment, the experimenter must define the required questionnaires and upload media content to the system. Then, the flow is materialized through the definition of the experiment phases, i.e. questionnaires and media content exposures. For every particular step in the flow, the experimenter has to select which questionnaire or media content to associate with the step at hand.

The experiment definitions are encoded in an XML format and persisted to the database. When a specific experiment is selected, the encoded XML is sent to the client side that parses it and constructs the UI according to its definitions.

3.4 Sensors Management

A sensor is a resource that collects data while the user is exposed to a media content during an experiment. There are various types of sensors and their availability is dependent on the client side technology. For instance, voice and audio can generally be collected from both smartphones and laptops using cameras and microphones, while GPS is typically only available on smartphones. Currently, four types of sensors are supported: (a) video sensor, (b) audio sensor, (c) motion sensors (d) location sensor capturing the device physical location using GPS.

Upon experiment completion, the client uploads collected data to the *Sensors Management module* which processes it in order to produce quantifiable measurements. For example, video clip of the user's face being exposed to content is being interpreted into a time chart identifying emotions over the length of the movie. For each of the four defined sensors types we have implemented a designated sensor plug-in that takes data as input and interprets it. The results are then persisted and later used by the *Analytics module* for analysis.

3.5 User Profile

The profile of a user participating in the experiments is managed by the *User Profile module*. Before participating in an experiment, each user must have an active profile configured in the system. Initially, the profile only contains the basic users' demographics information (e.g., gender, age, ethnicity, knowledge of languages) configured manually by them. But after participating in experiments the profile is enriched with experiments results. The data stored in the user's profile assists experimenters in defining the participating audience of a new experiment. In addition, there are some intra and inter user profile analytics; For example, aggregating user results across different experiments, scaling together the emotional response of various users to the same content, and more. Finally, the user profile is consumed by the *Analytics module* in order to perform different analysis either at the personal level or aggregated level.

3.6 Experiments Management

While the *Experiments Metadata Management module* is responsible for configuring an experiment metadata (i.e. questionnaires, media content selection, required sensors and visualization parameters), the experiments management is responsible to configure a specific instance of an experiment by doing the following : (a) configuring the life time of the experiment (days, weeks, months), (b) defining the required number of participants and their demographics (e.g. gender, age range, ethnicity), (c) defining the targeted users profile (for instance users that have never participated in an experiment or users that we identified to have an angry persona). In general, the idea is that different experiment instances could use the same experiment metadata with various configuration parameters.

3.7 APIs Gateway

This module centralizes the interaction between the application server and the client side across various technologies. It is a RESTful API over HTTP protocol that gets a request, parses it and forwards it to the relevant server side module.

3.8 Analytics

The *Analytics module* has three main objectives. The first one is to merge between the sensors outputs (e.g., combining the emotions extracted from facial expressions and speech). The second is to extract features from the content (e.g., extracting terms from textual data, or color histograms from an image, etc). The third one is to correlate media content, extracted features and emotions across users' profiles.

Figure 2 depicts the platform's modules interaction from the *Analytics module* perspective. In the *client's side*, the user is exposed to a media content which can be in the form of video, audio or text content, according to what the experimenter had configured in the *experiment metadata*.

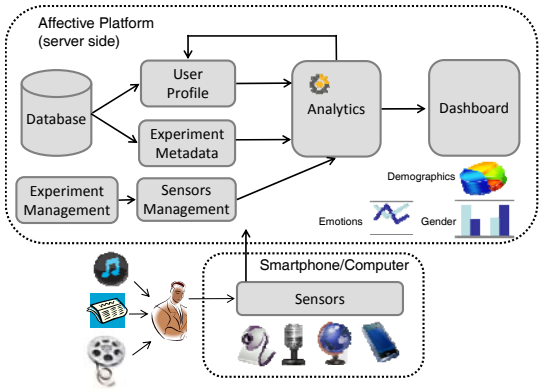

Figure 2: Data flow

During the experiment the sensors on the client's device (camera, microphone, motion detector, GPS) capture data and send it to the *Sensors Management module* in the server side for processing. Then, the *Sensors Management module* feeds the *Analytics module* with the processed sensors data. In case of video, for instance, it might be a graph describing the emotional status of the user in quantifiable metrics over time. Then, if needed, the module merges the different sensors signals into a coherent emotional state. Additional data providers are the *User Profile* and *Experiment Metadata* modules. The analytics module retrieves data about user's past experiments results from the *User Profile module* and feeds it back with the current analyzed experiment result. Furthermore, the *Analytics module* retrieves the current experiment settings (questionnaires and media content names) from the *Experiment Metadata module*.

4. USE CASE

In this section we describe a specific use case of the affective platform. In this use case, the goal of the experiment is

to collect data and to calculate correlations between users' information (such as demographics and personality traits) and expression of emotions by the user, as detected by a facial expressions recognition plug-in.

In the first part of the experiment, the user is asked to fill in two questionnaires which are available by the *Questionnaires Management module*: An extended demographic questionnaire and a mini-TPIP [5] questionnaire, which is a short (20 questions) personality traits questionnaire based on the Big Five personality traits model [4].

Upon experiment completion, the output of these questionnaires are used to measure correlations between user information attributes and emotions measured during exposure to media content.

The experiment is constructed of several repeated rounds, where each round contains two steps. In the first step, the user watches a short video-clip (15-30 seconds), and is recorded while watching the video-clip by the camera of a mobile device or a laptop. Each video-clip is selected from a collection of video-clips available by the *Media Management module*. These video-clips are highly likely to elicit an emotional response by the users who watch them, as they portray situations which are funny (e.g., slapstick accidents), disgusting (e.g., cruel animal hunting) or thrilling (e.g., wing-suit flying). The second step of the round starts after the video-clip playing is finished. In this step the user fills in a form where she states, on a scale of 1-5, which emotions, out of Ekman's Six Basic Emotions [6], where elicited in her while watching the video-clip.

There are total of five rounds in the experiment, so the user watches five different video-clips. Video-clips were selected to contain two "funny", two "disgusting" and one "thrilling" videos. After the rounds are over, the user is informed that the experiment has completed. The output, which consists of the questionnaires output (including the self reported emotion values for each video-clip), and of the video recordings of the user, is uploaded to the *Experiment Management module*.

The experiment detailed above is aimed to collect data from different demographic groups. Therefore, it is defined in the *Experiments Management module* that the experiment would be distributed uniformly across all demographic groups (gender and age group), with a target goal of 200 users in total.

After the goal number of users has been reached, the experimenter can start analyzing the experiment's output. The experimenter receives, for each user, an XML which describes the output for each questionnaire. Furthermore, the experimenter also receives the output of the *Sensors module*, which, for this experiment, is a graph specifying the identified emotions over the length of the video.

As a preliminary step, the output of the *Sensors module* is preprocessed by the *Analytics module*, such that for each emotion and each video, there is a single measure which represents the emotion level the user has expressed in the video (e.g., by averaging or aggregating emotion expression). The input, after preprocessing, contains records for each user and each video the user watched. These records are constructed of values for different families of variables: emotion expression (as calculated in the preprocessing step), emotion self report value, demographic data (gender, age group, education and income) and personality traits (output of the personality traits questionnaire).

The correlation, and significance of correlation, can then be calculated, using the *Analytics module* between variables of different variable families. For example, the correlation between a measured emotion and the corresponding reported emotion, a demographic variable or a personality trait variable

5. CONCLUSIONS

In this paper we described *Mindful*, an end-to-end affective platform to support and distribute large scale experiments. We discussed the different components, the flow, followed by a use case. Future work includes extending the analytics component to include more statistical capabilities and visualizations. We also intend to validate the system under more use cases by working with research groups in universities.

6. REFERENCES

[1] J. Bryant and D. Zillmann. *Responding to the screen: reception and reaction processes*. Communication Series. L. Erlbaum Associates, 1991.

[2] R. Calvo, M. Hussain, P. Aghaei Pour, and O. Alzoubi. Siento: An experimental platform for behavior and psychophysiology in hci. In *Affective Computing and Intelligent Interaction*, Lecture Notes in Computer Science. 2011.

[3] G. Churchill and D. Iacobucci. *Marketing Research: Methodological Foundations*. Marketing Series. Harcourt College Publishers, 2002.

[4] P. Costa Jr and R. R. McCrae. Neo personality inventory–revised (neo-pi-r) and neo five-factor inventory (neo-ffi) professional manual. *Odessa, FL: Psychological Assessment Resources*, 1992.

[5] M. B. Donnellan, F. L. Oswald, B. M. Baird, and R. E. Lucas. The mini-ipip scales: tiny-yet-effective measures of the big five factors of personality. *Psychological assessment*, 18(2):192, 2006.

[6] P. Ekman. An argument for basic emotions. *Cognition & Emotion*, 6(3-4):169–200, 1992.

[7] H. Eysenck and S. Eysenck. *Manual of the Eysenck Personality Questionnaire (Junior and Adult)*. Kent, UK: Hodder and Stoughton, 1975.

[8] R. LiKamWa, Y. Liu, N. D. Lane, and L. Zhong. Moodscope: Building a mood sensor from smartphone usage patterns. In *Proceeding of the 11th Annual International Conference on Mobile Systems, Applications, and Services*, MobiSys '13, 2013.

[9] R. Picard. *Affective Computing*. MIT Press, 2000.

[10] R. W. Picard. Affective computing: Challenges. *Int. J. Hum.-Comput. Stud.*, 59(1-2):55–64, July 2003.

[11] K. K. Rachuri, M. Musolesi, C. Mascolo, P. J. Rentfrow, C. Longworth, and A. Aucinas. Emotionsense: A mobile phones based adaptive platform for experimental social psychology research. In *Proceedings of the 12th ACM International Conference on Ubiquitous Computing*, Ubicomp '10, 2010.

[12] A. Tsui and B. Gutek. *Demographic Differences in Organizations: Current Research and Future Directions*. Lexington Books, 1999.

[13] J. Wagner, F. Lingenfelser, E. André, D. Mazzei, A. Tognetti, A. Lanatà, D. De Rossi, A. Betella, R. Zucca, P. Omedas, and P. F. M. J. Verschure. A sensing architecture for empathetic data systems. In *Proceedings of the 4th Augmented Human International Conference*, AH '13, 2013.

[14] J. Wagner, F. Lingenfelser, T. Baur, I. Damian, F. Kistler, and E. André. The social signal interpretation (ssi) framework: Multimodal signal processing and recognition in real-time. In *Proceedings of the 21st ACM International Conference on Multimedia*, MM '13, 2013.

[15] D. Zillmann and P. Vorderer. *Media Entertainment: The Psychology of Its Appeal*. Routledge Communication Series. Taylor & Francis, 2000.