Mood Meter: Counting Smiles in the Wild

Javier Hernandez *   **Mohammed (Ehsan) Hoque ***   **Will Drevo**   **Rosalind W. Picard**

Media Lab
Massachusetts Institute of Technology
Cambridge, MA, USA
{javierhr, mehoque, drevo, picard}@mit.edu

ABSTRACT

In this study, we created and evaluated a computer vision based system that automatically encouraged, recognized and counted smiles on a college campus. During a ten-week installation, passersby were able to interact with the system at four public locations. The aggregated data was displayed in real time in various intuitive and interactive formats on a public website. We found privacy to be one of the main design constraints, and transparency to be the best strategy to gain participants' acceptance. In a survey (with 300 responses), participants reported that the system made them smile more than they expected, and it made them and others around them feel momentarily better. Quantitative analysis of the interactions revealed periodic patterns (e.g., more smiles during the weekends) and strong correlation with campus events (e.g., fewer smiles during exams, most smiles the day after graduation), reflecting the emotional responses of a large community.

Author Keywords

Smiles, interaction, public display, longitudinal study, emotional representation, emotional response, privacy

ACM Classification Keywords

H5.m. Information interfaces and presentation: Miscellaneous; K.4.1 Privacy

General Terms

Design, Human Factors

INTRODUCTION

Ever wonder why people always looked very rigid and serious in portraits before the 1850's? In contrast, people mostly appear relaxed, spontaneous and smiling in modern portraits. While it is difficult to attribute this change to a single event, the development of advanced cameras has definitely played an important enabling role. For example, previously the exposure time of cameras was too slow to maintain a particular facial expression without trembling or inducing pain. As a result, most of the pictures would
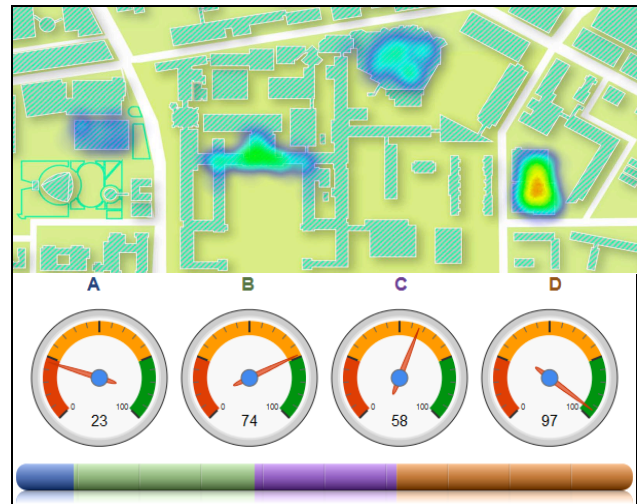

Figure 1. The top graph shows the campus map with the different locations (A, B, C, D) color coded in terms of smiles. The bottom graph displays the numerical values (0-100) of average smile per location as gauge meters.

appear unnatural and far from being spontaneous. With the development of computer vision technology, now it is possible to capture spontaneous moments of individuals with their emotional footprints at various time units.

In this paper, we created an interactive technology that enables a new type of live portrait of a community, creating a time-changing location-based emotional footprint. In particular, we created an interactive installation that automatically encouraged, recognized and counted smiles of participants strolling by, and deployed four of the systems at major locations on a college campus for ten weeks. The online portrait continuously showed the collected information in a variety of visualizations and interactive graphs. One of the visualizations, for example, overlaid the amount of smiles of each location on the campus map, with the "hotter" regions indicating a higher smile count (see Figure 1). At any given time, anyone from any part of the world could view the map display and the other interactive graphs at http://moodmeter.media.mit.edu and find out which part of the campus was smiling the most at that very moment.

---

* Both authors contributed equally to this work

The installations were designed first to be unique, fun, and engaging. However, we also had a number of serious research questions given that this was the first installation that we know of to deploy continuous 24/7 emotional expression reading technology of groups in public places. These questions include, "Is it possible to gain the trust of people with technology that records their emotional data 24/7, and how would this community receive this technology?", "Would there be any visible, repetitive pattern in the amount of smiles?", and "How would one analyze this new kind of data collected for an extended period of time?". In this paper, we address these questions in the context of a college campus, and reflect on how the findings could possibly be generalized both to other environments and to other applications.

The paper is organized as follows. First, we review previous work on creating the emotional portrait of an environment using various techniques. Second, we describe our project setting and outline some of the most relevant constraints. Third, we describe the proposed system and the details about the installations. Next, we provide a questionnaire-based analysis of the interaction of people with the system. Then, we quantitatively analyze the smile data and discuss some of the patterns of interaction. Finally, we provide some examples of future applications.

PREVIOUS WORK
In the past, people have obtained affective states of groups of people mostly by using self-reported measures. Most of these measurements were based on mood ratings questionnaires [20] or on non-verbal pictorial assessments [2]. With the development of technology, these measurements have been embedded in portable electronic devices [4, 16] enabling easy long-term and large-scale monitoring of emotions [8] such as happiness [4]. In an ongoing project called Mappiness [14], the authors developed a cellphone application to gather mood ratings of the inhabitants of the United Kingdom. Then, by aggregating all of the ratings, they created a representation of the self-reported emotional footprint of the country. Such mood ratings differ from our approach in that they require cognitive effort to use the application and to mentally map a feeling to an entry. A slightly different approach consists of analyzing the affective content of online forums. In a project called Pulse of the Nation [15], the creators analyzed the affective content of Twitter feeds to represent the mood of the United States of America. Although these projects use valid channels of affective information, they are considerably less direct and dynamic than natural facial expressions. An example of installation directly measuring affect from audience using cameras was demonstrated in a project called Feel-o-meter [21]. The authors measured the facial expressions of people standing in a single location and represented them on a giant smiley. Although the exhibition ran for 15 days, no evaluation was reported.

The meaning of facial expressions has been extensively studied for decades by cognitive, social and clinical physiologists. Among other expressions, smiles have been shown to have a bidirectional link between emotional experience and facial movement [17, 18]. That is, people smile because they feel happy, and smiling can help them feel happier. Moreover, some studies have shown that the act of laughter releases endorphins, which reduces stress [1] and, consequently, strengthens the immune system. Although smiles are not always indicative of good mood [6, 7], they are certainly associated with positive feelings such as well-being and happiness, and it is easily understandable why they have become the social convention in photographs. In fact, smiles have become so prevalent that people purposely induce them with standard words and sentences (e.g., "Say cheese!"), and modern commercial cameras automatically detect them to decide when to take the optimal picture. A recent study [19], explored the use of these cameras in household environments to enhance positive mood and prompt communication. Below we will also describe some findings suggesting that smiles elicited by our system momentarily improved mood of the participants. To the best of our knowledge, the system proposed in this work is the first to measure smiles in the wild to create an expression-driven emotional portrait of a large community.

CONTEXT, PROPOSAL AND PRIVACY
In order to celebrate the 150th anniversary of our university, the institute decided to have a five-month long festival that creatively combined arts with science and technology. As part of that effort, we proposed the project Mood Meter to capture the emotional portrait of the campus during ten weeks of festivities. Technically, "mood" refers to a long-term affective state (which could be negative or positive) and not to a snapshot of smiles. However, we thought smiles would be fun and more likely to be accepted by the community than, say, counting frowns. Moreover, smiles are also one of the more robust expressions for current affective computing technology to recognize accurately, at a distance, and over a variety of lighting and angle conditions. At one point we decided to change the name of the project to "smile meter" but the arts festival committee told us they strongly preferred "mood meter", so the final name is more slanted toward the arts than toward science, even though the project achieves both.

The proposed project described creating an interactive and real-time representation of the institution as a function of number of smiles at any point in time. We achieve that by installing cameras at several public spaces on campus. As expected, the proposal was immediately red-flagged by the university's security office as they felt that our project had the potential to compromise the privacy of campus individuals.

Protecting privacy has been a sensitive topic in the field of human-computer interaction for a long time [3, 8], and has

strongly influenced the design of ubiquitous systems [12]. Several studies (e.g., [5], [10]) have thoroughly analyzed the most relevant concerns of individuals in a variety of public spaces and applications (monitoring of education and linking public-spaces, respectively). Although most of the studies identify similar concerns, their relevance and the proposed solutions are very specific for their own experimental setting. After several iterative meetings with the Security and Institutional Review Board (IRB) of our university, we summarize the main concerns of our setting as: 1) preserving anonymity of participants, 2) informing participants how the system worked, 3) and complying with strict security protocols to secure the installations. In the next section, we describe the different parts of the system and how their design addresses those concerns.

DESIGN OF THE 'MOOD METER'

The system was based on a set of distributed installations that encouraged, recognized and counted the smiles of passersby.
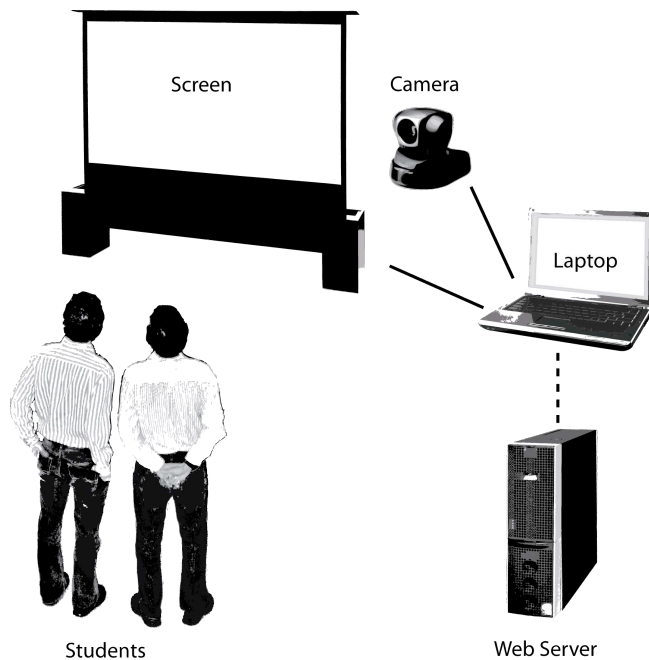
Figure 2. Schematics of one of the installations.

Figure 2 shows the schematics of one of the installations. Each camera was constantly capturing images (30 frames per second) and sending it to the laptop attached to it. The laptop was equipped with our custom vision software that automatically analyzed each image to find the number of faces and the intensity of their smiles. This information was then transmitted to the server. The server utilized the information to generate a public website with several interactive graphs that reflected the emotional footprint of the campus community. It is worthwhile to mention that data transmitted through the encrypted wireless connection to the server never contained any sensitive information that

Figure 3. Example of the interface, as people interacted with one of the installations. Green blobs indicate faces detected as smiling, while yellow blobs indicate non-smiling faces.

could be used to uniquely identify, track or monitor people while they interacted with the installation.

Interface

To make it more fun and engaging, we displayed the live-feed captured from the camera using projectors and large screens, as shown in Figure 3. Since some people may not enjoy looking at themselves on a large projector in public places, we intentionally drew blobs on each face. The interface overlaid a yellow neutral face if the person was not smiling ("smile intensity" < 50%) and a green happy smiley otherwise. (The measurement of "smile intensity" is explained in the next section). On the left side of the interface display, as shown in Figure 3, there is a smile-barometer that depicted the aggregated smile estimation for everyone present in the image. For example, if there are two people smiling with "smile intensity" values being 70% and 80%, the smile-barometer would have a value of (70+80)/2 = 75%. Although the face display is binary (neutral or smiley), every detected face contributes to the barometer score. To encourage further participation, each person got a bow tie drawn around his/her neck whenever the aggregate smile intensity reached above 50%. We noticed that this feature often led members of a group to encourage other members to smile. In order to promote transparency, the lower part of the image contained the disclaimer, along with the project website address, that clearly stated, "This is a live feed, no information is recorded." Moreover, there was physical signage next to the camera explaining the purpose of the installation along with privacy details. The website also contained information about the project and how it addressed privacy.

Smile Analysis Module

In order for the project to succeed, it was really important that the vision modules worked reliably to detect faces and smile intensities in real time. In terms of smile analysis, there were two major tasks: face detection and facial feature analysis to predict smiles. For face detection, we used the face detector described in [11], also known as the Shore framework. The Shore framework can detect small faces (as small as 8x8 pixels), allowing for people to be far away
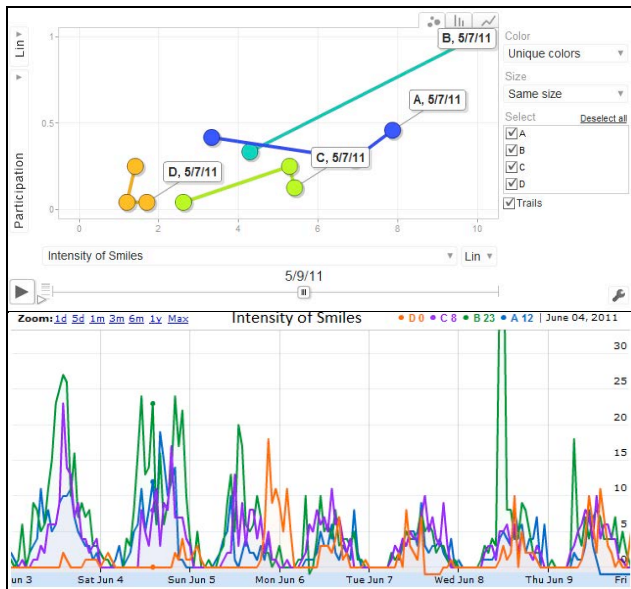
Figure 4. Interactive graphs of the website. The top graph allows visualizing the trails of smiles at each of the four locations as a function of smile intensity and number of people. The graph at the bottom represents the temporal evolution of smiles through time.

from the camera and yet be tracked with high accuracy. Once the vision module had detected all the faces, it utilized the Shore framework to extract several geometric properties of the faces that were then used to predict the intensity of a smile, ranging from 0% (non-smiling face) to 100% (very intense smile). The framework described above was tested on the JAFFE Dataset [13] which contained 178 images of facial expressions (happy, sad, surprise, angry, and disgust) with 29 instances of happy faces. Testing the smile analysis module on the JAFEE dataset yielded a recall of 1, precision of 0.69, and F-1 measure of 0.81. To establish the ideal environment for the vision system to work, we installed cameras in places where lighting and backgrounds were more likely to be constant during the entire exhibition. More evaluation data on our vision system will appear as part of our future publication.

Website
The anonymous information collected at each location (e.g., number of faces and the average intensity of their smiles) was sent every two seconds to an external server. The purpose of the server was to store, analyze and aggregate all the information and then display it on the webpage in various formats (Figures 1 and 4) - making it possible for anyone around the world to visualize the data and explore patterns on their own. Some of these visualizations included: 1) a real-time heat map of the campus with more colored areas where people smiled the most, 2) a real-time 3D map showing the amount of smiling faces over the buildings, 3) gauge meters showing the average intensity of smiles for each location, and

4) temporal graphs of time series data showing the intensity of smiles and number of people since the beginning of the installation. Moreover, we had set up platforms in Facebook and Twitter for people to express their views, share concerns or ask questions related to the exhibition.

Installations
We deployed installations at four of the busiest corners of the college campus. The sites included the entrance of the college student center, where students gather up to socialize (location, A), two main corridors (B and C), and an open area of an academic department that is in between several research groups (D). All of the locations were constantly open to the public, except locations C and D that required a college ID on weekends, and from 18.00 to 8.00 on weekdays. Each installation was located in different buildings and all of them were separated by at least 200 meters.

We used *Sony EVID100P CCD Pan Tilt Zoom* cameras in all the sites. We specifically chose this camera model because it could be operated using a remote controller, allowing the cameras to be mounted in inaccessible regions to prevent theft or vandalism. We used *Dell Vostro 3500* laptops with Intel(R) Core(TM) i3 CPU M350 (2.26 GHz), 3 GB RAM, and Windows 7 Home Premium 32-bit operating system or equivalent at each location. In order to display the interface, we used projectors at two of the locations (B and C) and large screens at the other two locations (A and D).

The duration of the deployment was ten weeks and our set up was fully compliant with the rules and regulations of our security and technology departments. The experimental setting as well as the system design was also approved by the IRB of the college campus before installation.

INTERACTIONS
This section describes a qualitative analysis of the interactions of college members with the system. We divide our analysis in three parts: 1) types of interaction, 2) the impact of these interactions on smiles and affect and, 3) the perception of the system by the college community. We report on responses from 300 college members, including undergraduates, graduates, faculty and staff, who voluntarily answered a survey. The survey was sent to several mailing lists of the university after the completion of the exhibition, and contained several 7-Likert scale questions assessing the quality of their interactions with the system. In addition, survey respondents were asked to briefly describe their interaction with the system. To encourage participation, all questions were optional and a second survey was created with a smaller subset of the questions. Table 1 summarizes the survey questions and their responses.

Questions	1- Lowest point label	7- Highest point label	% > 4	ME	SD	N
1. Were you less or more likely to interact when you had free time? *	Less	More	79.51	6	1.49	122
2. Were you less or more likely to interact when there were more people?	Less	More	18.85	3	1.58	191
3. Were you more inclined to interact when your mood was... ?	Negative	Positive	71.59	6	1.36	264
4. Did it ever make you smile?	Never	More than I expected	79.32	6	1.53	266
5. If it made you smile, how much did it affect your mood?	Momentarily Worse	Momentarily Better	75.68	5	1.25	259
6. If you saw other people interacting with it, how did their mood look like?	Momentarily Worse	Momentarily Better	82.49	6	1.06	257
7. Seeing them, how did it affect your mood?	Momentarily Worse	Momentarily Better	65.37	5	1.35	257
8. How intuitive and easy was to figure out what it was doing? *	Hard	Easy	95.12	7	0.91	123
9. How well did it detect smiles? *	Really Poorly	Really Great	70.83	5	1.36	48
10. How accurate was the barometer? *	Completely Wrong	Very Accurate	78.70	5	1.36	46
11. Did you find the project... ?	Very Intrusive	Non-Intrusive	73.03	6	1.70	267

Table 1. Summary of people responses. %>4 = Percentage of ratings above four (the middle point), ME = median value, SD = standard deviations, N = number of responses. * Removed questions from the second survey.

Types of Interaction

Over the ten weeks of installation, thousands of people interacted with the system. Although each interaction varied from person to person, there was a very similar response for first-time interactions. As soon as people discovered themselves on the displays, they seemed surprised and confused and, seconds after that, they started testing the system by moving their head and occluding their face. As they noticed that smiles triggered some changes in the interface, they started alternating frowning and smiling faces to manipulate the barometer. In less than a minute, their interaction quickly became an amusing experience that was most commonly described as *"Cool!."* On the other hand, the people who were already familiar with the system showed multiple types of interaction, such as the ones described by the following person:

"I enjoyed both my own interactions with it (sometimes purely passive, other times I enjoyed teasing it actively...) and watching others engage with it."

Two locations involved labs that sometimes see each other as rivals. On a few sporadic cases, students from one department, printed smiling faces and hung them in front of the camera to obtain the highest barometer readings of the campus (see top image of Figure 5). These segments were excluded from the quantitative analysis of the next section.

As expected, survey responses indicated that people preferred to engage in interaction with the system when they had more free time (question 1) and were in a positive mood (question 3), suggesting that the smile-barometers should be high after classes or on the weekends. To a lesser extent, people also preferred to interact when there were fewer people (question 2). However, one of the responses noted that familiarity with people was an important factor:

"If I was with a large group of friends, I was more likely to interact. If I was in a large group of strangers, I was less likely to interact."

In fact, several people reported to engaging in collaborations to test the system, one example was:

"I stood and tried to get people around me to smile so we could get the thermometer thing to go as high as possible."

Impact of Interactions

As outlined in previous sections, smiles are a powerful facial expression that may influence how people feel.
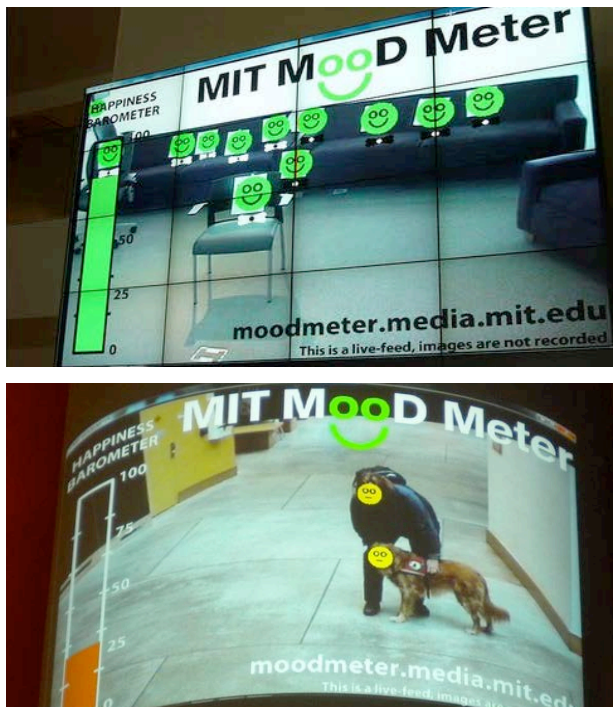
Figure 5. (Top) students printed several smiling faces and hung them to increase the smile-barometer, and (bottom) the software detected the face of a dog.

Through our survey we wanted to assess if the system had any impact on the amount of smiles and, consequently, on the affective state of people.

When survey respondents were asked if the system made them smile (question 4), 96.62% of them answered affirmatively (% of ratings > 1). For these people, 75.68% reported a slight positive impact on how they momentarily felt (question 5). The specific reasons of why people smiled were very personal and varied. Some comments described their reasons as:

"It was definitely a great way to remind yourself to smile - just like seeing someone smile or a baby might do!"

"I became a little more aware of what my projected mood was and I smile to make it better."

"It made me smile every time I saw it because it reminded me that I am part of a greater community."

"One night I was walking down the [location B] at 4am and decided to try and max out the mood meter. Another guy walking down the corridor behind me stopped and helped me. Given that it was 4am and we were on campus, it was a very nice sort of relief and brought us together momentarily!."

People reported feeling more positive not only when interacting with the system but also when seeing others interacting with it (question 7). One of the respondents said:

"I found that watching other people's reactions and interaction with the system even more enjoyable. Especially visitors."

Interestingly, people perceived the system to have significantly more positive impact on the mood of others (question 6) than their own ones (Two-sample t test, $p < 0.05$).

On the other hand, some people were annoyed by the large crowds that sometimes gathered up to interact with Mood Meter, especially for one of the corridors (B).

"[I] Enjoyed it in the beginning, but then it got annoying when people started blocking halls to dance in front of it."

Very few people reported general negative feelings about the installation, but there were some:

"I found it annoying, like I'm supposed to act happy for it, or it's trying to force me to be happy, which pushed me toward being less happy."

Perception of the System

The acceptance and overall perception of a system by the community is of paramount importance to ensure satisfactory long-term interactions, as the one proposed in this study. This section summarizes some of the critical parts such as privacy, usability and performance.

Overall, people perceived the system as non-intrusive (question 11), although some respondents expressed their reservations with the cameras:

"I don't like the idea of cameras in general, even if they are not permanently recording/storing/transmitting data."

Moreover, there was a strong response indicating that the system was easy and intuitive to understand (question 8). In regard to the interface, people described the performance of both the smile-barometer (question 10) and smile detection (question 9) as satisfactory. Some people commented on the positive effects of real-time feedback for smooth interaction:

"I enjoyed it because it was quick and immediate."

"It was interesting to play with it to see how responsive it was and how fast it could update."

Some others suggested to recognize other facial expressions, specially frowning, to make it more interactive:

"I do wish that it would do some frown, or other facial emotional detection; it would make it more fun to interact with."

In some other cases the software had unexpected outcomes (see bottom image of Figure 5) that made the interaction more enjoyable:

"I loved it when we discovered that the Mood Meter in [location C] could pick up our dog's face. After that, we tried many ways to get it to register her as a 'smile'."

PATTERNS OF INTERACTION

This section explores the visualization and analysis of the data logged by the system every two seconds at each of the four locations. Due to the positivity associated with smiles, and the long-term nature of the installations, we wanted to see if there would be any identifiably and meaningful patterns that could provide quantitative information about the community. To better study that phenomenon, we define two interaction components as units of analysis at different time granularities: day, week and month. These components are:

- Average Smile Intensity (ASI): Given a time period, this value represents the average value of the smile-barometers whenever people interacted with the system (i.e., whenever the software detected at least one face). For instance, when analyzing one day of the week, we took all of the smile-barometer values of that day and computed the average.

- Amount of Participation (AP): This parameter is an indicator of the number of participants who interacted with the system. Since the system cannot track people across time, we averaged the number of detected faces per frame, and divided the result by the maximum observed value over a time period. Therefore, the range of AP values is between zero and one for a given time period.

In order to give the same relevance to the four locations, the variables ASI and AP were computed independently for each location and then averaged across locations. In two of the following analysis (Daily View and Weekly View), where we attempt to understand the college environment, we excluded dates of major events (April 31, May 7-8 and June 2-3). During those dates, the university organized several events with thousands of visitors, which would have skewed the average values of AP and ASI.

Daily View

Figure 6 shows the average evolution of the ASI (left) and the AP (right) during a time granularity of a day. In other words, Figure 6 demonstrates the patterns of ASI and AP during the 24 hours span of a typical day averaged over the ten weeks.

The trend of ASI starts increasing at 7:00 in the morning and continues to increase slightly during the day. Meanwhile, the AP starts increasing with the beginning of classes at 8:00 in the morning and shows multiple peaks between class hours. That makes sense because usually classes end 5 minutes before the hour and students utilize that time to move to their class resulting in high AP values. The pattern of peaking every hour for AP tends to gradually dissolve after 16:00. Interestingly, while the participation is very low from 23:00 to 1:30, the intensity of the smile-barometers is fairly high which correlates with the survey responses about free time and likelihood of interaction (questions 1 and 2).
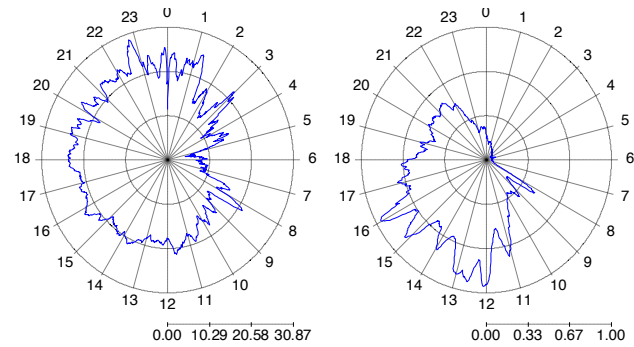

Figure 6. (Left) ASI and (right) AP during the day.

When correlating the signals for AP across each of the locations, the more social areas (A and D) were the most correlated. Similarly, the corridor locations (B and C) had the highest correlation when considering ASI. This finding indicates that both interaction components could provide insightful information to better understand and discriminate between patterns in different types of environments.

Weekly View

Figure 7 shows the average evolution of the ASI and the AP during a time granularity of one week (Monday to Sunday). The graph of ASI demonstrates that people smile significantly more at the end of the week than during the week days (Permutation Test, $p < 0.002$). Interestingly, the gradual change of ASI (e.g., highest on Saturday, lowest on Tuesday) is consistent with the day-of-the week happiness results reported in [14] even though those findings were in the United Kingdom and ours were in the United States. Meanwhile, the AP histogram shows quite the opposite patterns for participation. Wednesday seems to yield the highest participation (PT, $p < 0.002$), which gradually lowers during the next few days, with lowest participation being over the weekend (PT, $p < 0.003$). Although there are always fewer people expected to be in the labs and corridors over the weekend, it is interesting, yet not surprising, to see the low level of participation on Mondays.
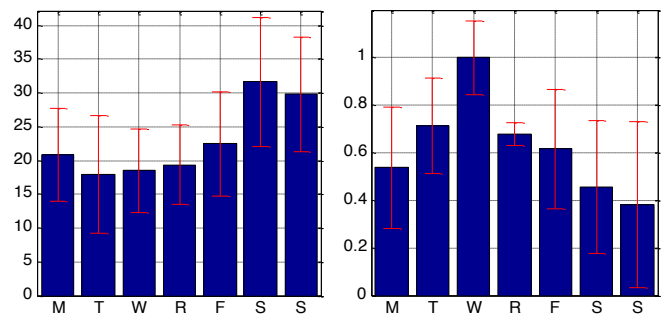

Figure 7. Average and standard deviations of (left) ASI and (right) AP during the week.
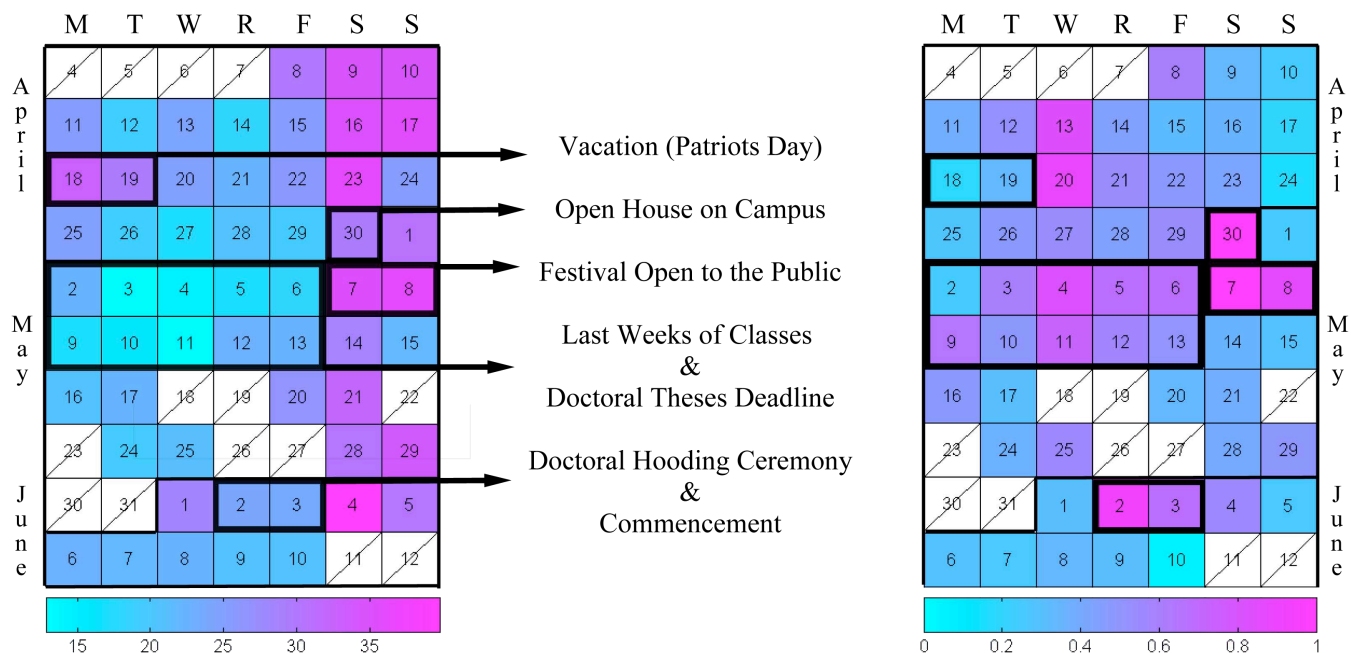
Figure 8. (Left) ASI and (right) AP during the study, and their color legend at the bottom of the figure.

Calendar View

Figure 8 shows the average of the ASI and the AP for each day of the installation. This is probably the graph that best captures the idea of creating an emotional portrait of the campus, color-coded as a calendar. Just by looking at the calendar, we get an instant feeling for each day in terms of ASI and AP. It is also very interesting to observe how the color-coded days seem to correlate well with the events happening around campus. Here are a few representative events:

- April 18 and April 19. These days were vacations due to Patriots day. As it can be seen, both ASI and AP show very similar values to most of the weekends: lower participation but higher intensity of smiles than working days (PT, $p < 0.006$).

- April 30. This was an open house where all the research labs of the institute opened up for the general public to showcase research projects. The event lasted for mostly the entire day and was attended by approximately 20,000 guests. According to our emotional calendar, this day yielded the highest participation level.

- May 7 and May 8. This two-day event was the main celebration of the festival. The college opened its doors to the public and showed all of the exhibitions that students had prepared, including Mood Meter. The event lasted both evenings and there were a large number of visitors interested in exploring and interacting with all of the installations. Although the agenda of both days was very similar, there was 13% more participation on May 7th (Saturday) probably due

to the novelty of the event. However, May 8th (Sunday) scored slightly higher in terms of smile intensity. Although the difference is not significant, it rained on Saturday, suggesting a possible subtle influence of the weather conditions.

- May 6 and May 12. These two days correspond to the deadline for doctoral theses and the last day of classes, respectively. As in many colleges, these weeks are the most demanding of the semester because students need to finish problem sets, class projects and study for exams. Although the participation is relatively high, the working days before these two dates had the lowest ASI of the entire calendar (PT, $p < 0.04$).

- June 2 and June 3. Finally, these dates correspond to the doctoral hooding ceremony and the commencement, respectively. While the first event had the highest participation (PT, $p < 0.009$) during a weekday (probably due to the presence of family members), the day after the commencement registered the highest intensity of smiles of the calendar (PT, $p < 0.003$). This could be the fun empirical fact that people are more likely to smile intensively after they have received their degrees.

The analysis of the interactions of people with Mood Meter reveals periodic patterns and strong correlations with campus events. The specific findings of this study are very aligned with traditional expectations of a college community, which suggest that simple interaction heuristics such as ASI and AP can reflect the community response to different events.

DISCUSSION

In this paper, we designed, implemented and evaluated a new interactive system that ensures engagement, spontaneous interaction, awareness and novel emotional data collection *"into the wild."*

We instrumented four major locations of a college campus with live stream cameras and analyzed people's smiles for ten weeks in real time. We also added a web component, updated every two seconds; where people around the world could view several interactive graphs reflecting the amount of smiles during the various campus events. To the best of our knowledge, we are probably the first to ever employ sensors (cameras and facial affect-reading software) that directly measure smiles to monitor a community 24/7 in a longitudinal study.

Installing cameras in public spaces and running this study for an extended period of time yielded many privacy challenges. In this study, we summarized some of the most relevant concerns in a college community, and learned that people can feel comfortable with cameras being on constantly when the interaction is fun and they have a clear idea of what it is about. For example, the form factors of the interface were designed in such a way that it was very intuitive for people to understand the purpose of system. As soon as a face was detected, the interface drew a blob around it, which would change its color as someone smiled or stopped smiling. Additionally, we realized that user anonymity ensured maximum spontaneous participation with such interfaces. For instance, we made it very clear, by making it a part of the interface, that we would not be storing any images from the interactions. We feel that this key feature instilled confidence in people on campus even though a lot of people still may hold negative feelings towards cameras and what they can detect.

The survey responses indicated that most people interacted with the system when they had some free time and/or when they were in a positive mood. Additionally, many individuals were more inclined to interact with the mood meters when they were in a group with friends, and less likely to interact with it when surrounded by strangers. Many stated that they briefly felt better after interacting or seeing others interacting with the mood meters. In other words, some part of the college community thought of it as a positive mood booster.

The analysis of interaction data showed that both intensity of smiles and amount of participation can be recorded continuously and used to help better understand the community. For instance, even though there were fewer people around over the weekend, they all smiled more intensively. There is also a trend for students to smile more after classes. We demonstrated a monthly calendar color-coded in terms of smiles which indicated that the smile parameters are largely correlated with academic events and festivities of the college. For example, smile intensities were measured to be the lowest during the exams period and highest the day after graduation. These findings indicate that long-term analysis of interactions with the system can provide insightful information about the environment, the community and their emotional responses to different events.

FUTURE APPLICATIONS

The overwhelming amount of positive feedback from the community regarding the study made us optimistic about future potential applications of Mood Meter. For example, if a public speaker could view the live heuristics of his/her audience's smiles, it would help the speaker to find the appropriate moment to restate a point, speed up or inject humor. Similarly, imagine the profession of a comedian. Currently, comedians rely on the sound of laughter, applause, and other qualitative observations to get a feel for which jokes are perceived as the funniest by the audience. Using Mood Meter, we could easily generate a smile track of the audiences in fine grained resolution, allowing comedians to get a feel for which jokes/words/expressions are yielding the maximum amount of smiles. Mood Meter could also be used to gather information of large communities such as conference attendees, museum visitors or store customers. Similarly to our deployment in a college setting, the amount of participation and intensity of smiles could help to better understand the people and their response to certain events.

In a completely different set of applications, it might be possible to measure how stressful a environment is by utilizing our technology and design considerations. The top executive of a company may not have time to interact with every possible employee of the company to get a feel of how they are doing. But if somehow, the executive could view an anonymous summary of decreasing smiles among employees, it could serve as very useful feedback. Moreover, the system could be installed in strategic locations such as social areas or waiting rooms to entertain and boost the mood of people. At the same time, if the principles we worked hard to instill in Mood Meter were not followed – if people were surveilled without their knowing, and information were given only to those in power, then this technology could be potentially harmful.

CONCLUSIONS

This study presents a large-scale and long-term deployment of a new system that captures and reflects the emotional responses of a community. We evaluated the interaction of people and the effectiveness of the system in a college setting, and found self-reported mood improvements in a survey of 300 people. Furthermore, the information collected through the interactions with the system provided insightful information to better understand the community.

In the future, it would be interesting to do a follow up study while turning off the projectors to see the differences in privacy concerns and intensity of smiles. In that case, the cameras would have to be installed in more social areas

such as dining halls where people are more likely to display their emotions. As suggested by some of the survey responses, it would also be interesting to include other facial expressions such as frowning that could potentially capture the negative responses of the community.

In summary, Mood Meter was both a scientific experiment and an interactive installation, and succeeded in creating a novel emotional portrait of a public environment while respecting people's feelings and privacy. This study generated new scientific insights - and drew plenty of smiles - from a college community campus, and we look forward to a future when similar technologies can empower other communities toward greater social awareness and self-discovery.

REFERENCES
1. Bennett, M. P., Zeller, J. M., Rosenberg, L., and McCann, J. The effect of mirthful laughter on stress and natural killer cell activity. Journal of *Alternative Therapies in Health and Medicine* 9, 2 (2003), 38–45.

2. Bradley, M. M., and Lang, P. J. Measuring emotion: the Self-Assessment Manikin and the Semantic Differential. Journal of *Behavior Therapy and Experimental Psychiatry* 25, 1 (1994), 49–59.

3. Boyle, M., and Greenberg, S. The language of privacy: Learning from video media space analysis and design. Journal of *Human Computer Interaction*, 12, 2 (2005), 328-370.

4. Csikszentmihalyi, M., and Hunter, J. Happiness in everyday life: The uses of experience sampling. Journal of *Happiness Studies* 4, 2 (2003), 185–199.

5. Hayes, G. R. and Abowd, G. D. Tensions in designing capture technologies for an evidence-based care community. In *Proceedings of CHI 2006*, ACM (2006), 937-946.

6. Hoque, M. E., and Picard, R. W. Acted vs. natural frustration and delight: Many people smile in natural frustration. In *Proceedings of F&G,* (2011), 354–359.

7. Hoque, M. E, McDuff, D. J., and Picard, R. W. Exploring temporal patterns in classifying frustrated and delighted smiles. Journal of *IEEE Transactions on Affective Computing*, *PP*(99), (2012), 1-13.

8. Friedman, B., Kahn, P. H., Hagman, J., Severson R. L., and Gill B. The watcher and the watched: social judgments about privacy in a public place. Journal of *Human Computer Interaction*, 21, 2 (2008), 235-272.

9. Isomursu, M., Tahti, M., Vainamo, S., and Kuutti, K. Experimental evaluation of five methods for collecting emotions in field settings with mobile applications. International Journal of *Human-Computer Studies* 65, 4 (2007), 404–418.

10. Jancke, G., Venolia, G D., Grudin, J, Cadiz, J. J. and Gupta, A. Linking public spaces: technical and social issues. *In Proc. CHI 2001,* ACM (2001), 530–537.

11. Küblbeck, C., and Ernst, A. Face detection and tracking in video sequences using the modified census transformation. Journal of *Image Vision Computing*. 24, 6 (2006), 564–572.

12. Langheinrich, M. Privacy by design - Principles of privacy-aware ubiquitous systems. In *Proceedings of Ubicomp* (2001), 273-291.

13. Lyons, M., Akamatsu, S., Kamachi, M., and Gyoba, J. Coding facial expressions with gabor wavelets. In *Proceedings of F&G* (1998), 200–205.

14. MacKerron, G., and Mourato, S. Mappiness. http://www.mappiness.org.uk

15. Mislove, A., Lehmann, S., Ahn, Y.Y., Onnela, J.-P., and Rosenquist, J. N. The Pulse of the Nation. http://www.ccs.neu.edu/home/amislove/twittermood/

16. Pollak, J. P., Adams, P., and Gay, G. PAM: a photographic affect meter for frequent, in situ measurement of affect. In *Proceedings of CHI 2011*, ACM (2011), 725–734.

17. Soussignan, R. Duchenne smile, emotional experience, and autonomic reactivity: a test of the facial feedback hypothesis. Journal of *Emotion* 2, 1 (2002), 52–74.

18. Strack, F., Martin, L., and Stepper, S. Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. Journal of *Personality and Social Psychology* 54, 5 (1988), 768–777.

19. Tsujita, H., and Rekimoto, J. Smiling makes us happier: enhancing positive mood and communication with smile-encouraging digital appliances. In *Proceedings of Ubicomp 2011*, ACM (2011), 1–10.

20. Watson, D., Clark, L. A., and Tellegen, A. Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of *Personality and Social Psychology* 54, 6 (1988), 1063–1070.

21. Wilhelmer R., Bismarck J., and Maus B. Feel-o-meter: Stimmungsgasometer. (2008). http://www.fühlometer.de