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Toward Ambient Intelligent Systems for Improving Levels of Creativity in Arts Learning Environments

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Abstract. Affect plays an essential role in the creative ideation of artists. This paper presents work in developing an intelligence framework for augmented environments with the aim of facilitating higher levels of creativity in arts education environments. We base our study on data collected from students at a leading US arts institution, as well as other research, that have shown a direct correlation between positive mood and high-levels of creative ideation. This paper discusses several participatory sensing methods we have employed in collecting affective information, the ongoing development of an intelligence framework, and several ways in which we are working to apply this framework in augmented art environments.

Keywords. Affect, creativity, arts education, context awareness

Introduction

Affect is essential to human intrapersonal and interpersonal interaction; as such, affect plays an important role in how individuals experience the world and apply themselves in activities. Research has shown that environmental factors can have a major impact on affect. For artists, it is important to work in environments that are conducive to creativity. An artist's studio is often designed not only to facilitate the end goal of producing works, but also to facilitate the lower level processes of creative inspiration and ideation (in a way that directly and affectively contributes to the artist's creative output). Since the Académie des Beaux-Arts first organized art education in Paris in 1648 [2], art education has moved from the Atelier method of master-apprentice workshop training, to formal institutionalized education in specified artistic disciplines. As it is known that environmental factors play a significant role in affect, and affect plays a significant role in the act of creative ideation, imagine being able to design environments based on information collected about the mood of art students in relation to certain environmental aspects. Such research could lead to a more creative artistic output and would be conducive to a creative community.

The field of affective computing is interested in using computers to recognize and recreate affect [1]. Researchers in the field of affective computing have long been

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[2] Plato's writings date the first recorded "art schools" back to 400 BC Greece

interested in the relationship between affect and creativity. Several studies have examined the interdependencies of these two phenomena and how they contribute to creative ideation. Sowden and Dawsen show the effect of mood on creative ideation and evaluation in [2] and a direct correlation between positive mood and creative output is shown in [3]. Feist examines several theories about affect and creativity in artists, and valuable insight illustrating that both positive and negative affect can contribute to increased levels of creativity in artists [4]. There have also been studies that show the impact of affect on academic performance in educational settings. These studies question how affective environments can contribute to better learning in schools and a higher level of academic production from students [5] [6].

Additionally, studies have investigated the effects that moods induced from art, specifically music, have on creativity. Adaman and Blaney show that elated subjects scored significantly higher than depressed subjects in creativity, and that both of these groups outscored neutral subjects [7]. Also, some have criticized the traditionally accepted connection between positive mood and creative output, illustrating that in some cases positive mood may impair creativity, where as negative and neutral moods could enhance it [8][9].

Through the current study being run at California Institute of the Arts, we are seeking to produce novel ways in which affective information collected through participatory sensing can be used to modify augmented art environments towards energizing higher levels of creativity. The current methods of data collection are described in section 1, while section 2 discusses preliminary findings in the development of an intelligence framework. Section 3 highlights some areas we are currently working to implement this framework, and we conclude with a discussion on future developments.

1. Method

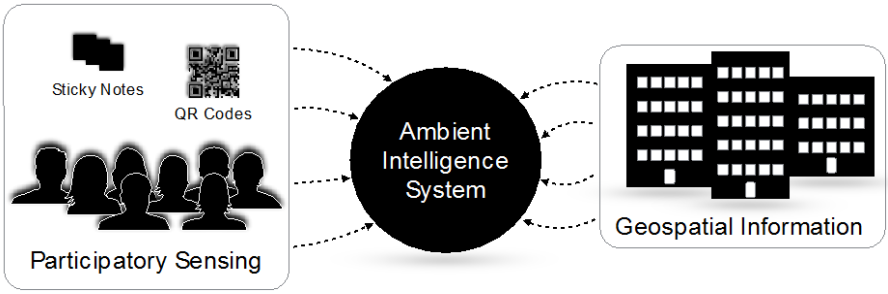

Figure 1. Overview of System

1.1. System Design

The system employed in this research was designed to measure affect, specifically mood, in an art school. Two collection methods were used: sticky notes, and QR codes. Students would record information concerning their current mood using these methods, which would then be stored in a database. This approach to facilitating creativity is supported by research that demonstrates creative self-efficacy can lead to enhanced creative performance [10]–[12].

1.1.1. Sticky Notes

California Institute of the Arts (CalArts) presents unique challenges to developing participatory sensing studies. As one of the world's leading contemporary art institutions, it houses some of the top creative young minds. The walls of the institute are covered in art and flyers, serving as a means of expression and communication among the student body. Thus to encourage participation, sticky notes were used as the first method of collection. Previous work has shown sticky notes, or Post-it notes, and note based systems to be an effective way of collecting affective and locative information for the development of context awareness [13], [14].

In the sticky note method, participants were ask to place sticky notes on different locations throughout the hallways at California Institute of the Arts. The color of the notes corresponded with specific mood indicators (Orange = Negative, Yellow = Neutral, Green = Positive). In the contents of the notes, participants were asked to include a timestamp and a short reflection on their current mood.

Instructions were provided on posters alongside the sticky notes to inform students how to fill out and participate. An initial thirty-five posters with these instruction and sticky notes attached were placed throughout CalArts.

1.1.2. QR Codes

The second data collection method examined is through mobile crowdsourcing. In the initial run of this experiment, we have designed a platform independent method that uses QR codes to direct the student to a short web-based questionnaire. The QR code method allowed students to scan a QR code poster in their respective hallway that was indicative of their current mood (Negative, Neutral, Positive). This form asked four additional questions: 1) The student's gender (male/female), 2) the number of people present in the hallway (0-2, 3-5, >5), 3) the option to add a more specific mood descriptor, and 4) how "creative" the student was feeling (scale: 1-5, with 1 being not creative, and 5 being extremely creative).

Eight posters were posted, covering two primary hallways within four departments (Animation, Dance, Music, and Theater). Additionally, instructions on how to scan the QR codes and recommended mobile applications were posted next to the QR code posters. The project was advertised in daily school announcements, bulletins, and via social media.

1.1.3. Geospatial Information

In addition to the data collected from the participants input, information was collected about the location in which the information was reported. This placed reported moods in relationship to features such as the size of the hall, lighting conditions, and activity level, in order to form the basis of an intelligence system based on ambient geospatial information. Further discussion is provided in section 2.1.

2. Proposed Framework

Based on the collected information, we propose a framework that clusters hallways based on user input, and in real-time, outputs information about a particular hallway's mood distribution as well as creativity levels. The structure of this system is shown in

Figure 2. There are multiple benefits to this real-time system. It allows for the development of artistic applications capable of online adaptation (see section 3). It encourages user participation by offering immediate feedback of their effect on the environment. Furthermore, it allows for the system to modulate the information of specific localities. This is especially relevant at CalArts, where spaces are often spontaneously transformed into art installation and galleries.

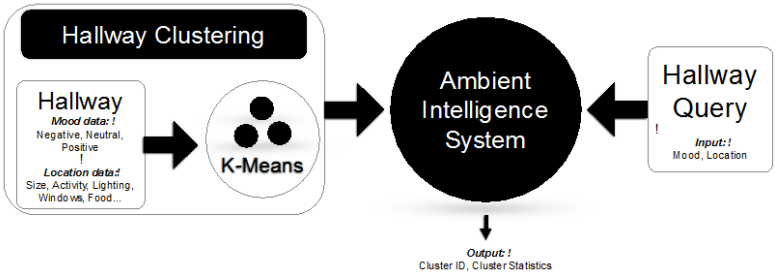

Figure 2. Clustering System

2.1. Pilot Results

This system is currently being evaluated in the data mining software WEKA [15]. The data is clustered according to Euclidean distance using the simple k-means unsupervised learning algorithm. When a particular hall is queried, it's cluster number and statistics are output. The increment for cluster reevaluation can be manually set by the programmer to re-cluster after a given set of inputs.

An initial pilot study of a two-weeks was set to evaluate the feasibility of an intelligence system based on mood and creativity identification and facilitation. In this time period, 129 data entries were collected. In this pilot data, we found a significant positive correlation between mood and self-reported creativity levels (Pearson's r=0.68, p=0.0098), which affirms the relationship demonstrated in several related studies [3]. The data was used to form 5 clusters. The cluster data is shown **Table 1** - the rows of the table represent the attributes, while the columns represent the cluster centroid. Attributes were described in vectors; {-1,0,1} is used for size (small, medium, large), lighting (dark, average, well-lit), and activity (low, average, high). Food and windows are represented in {0,1} (Boolean) and mood is represented in {Neg,Neu,Pos}.

Table 1. Hallway Clusters.

	C0	**C1**	**C2**	**C3**	**C4**
	16%	16%	10%	23%	35%
Size	0.75	1	-0.38	0.5	0.64
Lighting	0.25	0.76	-0.62	0.27	0.40
Activity	0.05	0.95	-0.46	0.07	0.18
Food	0	0.48	0	0	0
Windows	0	1	0.15	0.27	0.47
Mood	POS	POS	POS	NEU	NEG

3. Application in Augmented Art Environments

Spencer and Baum [16] illustrate that design characteristics such as social density, referred to as activity level in this study, affect people both directly and indirectly.

Design changes have been shown to increase positive mood in educational environments [17]. Just as office environments have incorporated space planning to maximize creativity and mental agility [18], its is crucial for art institutions to similarly do the same. While there are limitations to what can be done to the physical structure of the school, augmented multimedia environments offer an interesting and artistic paradigm for us to explore [19]. We are currently working to incorporate this intelligent framework into several existing projects that aim to develop augmented art environments through both projection mapping research and groundbreaking learning environments.

3.1. Projection Mapping

In a matter of just a few years, projection mapping has gone from laboratory ideas of calibrating projections onto target surfaces [20], to one of the most captivating and unique ways of augmenting surrounding architecture. Artists have transformed the role of 3D projection mapping into the design and digitalization of cities [21]. At Calarts, we have developed several frameworks for projection mapping and have deployed in performances and installations throughout the institution [22].

3.2. Augmented Classroom Environment

We are also interested in the direct impact of this system in the classroom environment. Kapur and his colleagues have developed an innovative curriculum for teaching computer science to creative artists at Calarts [23]. In Kapur's *n2n* learning system, he has transformed the learning space into a multimodal interactive environment in which each student has a large scale high-definition mobile display and audio system. This system allows both the students and instructor to share their works with the entire class. The name *n2n* means "many-to-many", as opposed to the traditional "one-to-many" teaching structure. We are working on ways in which can apply this intelligence framework in that setting.

4. Discussion & Conclusion

This paper presents an intelligence framework that aim to facilitate higher levels of creativity in arts education environments, specifically, California Institute of Arts, one the worlds leading arts institutions. The results of preliminary data have reaffirmed several standing theories about the relationship between affect and creativity. Through clustering this data, we are able to get a better look at what environmental factors may be contributing to affect, and also begin to predict and modify the condition of certain localities through augmented reality and projections.

We have currently tested two methods of data collection through participatory sensing: sticky notes and qr codes. Each method had its benefits. Sticky notes have the effect of immediate feedback back, and act as a sort of graffiti. Students see sticky notes and want to add their own sentiments to the walls, but unfortunately, this data has to be manually collected. The QR code method provides a simpler method to collect and organize data, but do not have the immediate feedback of sticky note method. Ultimately, we want to combine the best aspect of both of these methods. One way we are considering doing this is through the use of localized LCD displays that accompany

the augmented environments, and allow for real-time display of user input. Furthermore, we would like to abandon the predefined questionnaire for a more genuine expression of creativity. We plan to accomplish this through a larger framework for text mining. This will benefit from the collection of more data in order effectively train the system to detect user sentiment.

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