An Interdisciplinary Arts and Engineering Initiative for Experiential Multimedia+

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Abstract
The engineering, arts and science disciplines involved in media training, research and education at Arizona State University have come together to create the Arts, Media and Engineering (AME) graduate education and research program. The education component of this program consists of formalized graduate concentrations within existing degrees that allow faculty and students to combine extensive training in their chosen discipline offered through their home department with hybrid engineering-arts-sciences training offered through AME. This paper states a basic education and training problem in arts and media and presents a program that was formed at Arizona State University to address this problem. The structures, participation, associated sub-areas of this program are also described.

1. Introduction

The ASU arts and media (AME) program aims to produce a new kind of hybrid graduate students who draw their creativity from the arts and their methodology from the sciences. The program trains students to integrate principles of computing and communication with artistic ideas and objectives, with the goal of enabling new paradigms of human-machine experience that directly address societal needs and facilitate knowledge. The students' research activities will focus on how the computer mediation of experiences can facilitate the evolution of the information age into the age of digitally enabled knowledge. Our vision and plans are predicated on two ideas:

- Civilizations are after deep, useful knowledge
- Most human knowledge results from experience.

The need for this information to transcend into experience and then knowledge is rarely addressed. Historically, the arts have been crucial in allowing civilizations to experience truths about their state and thus acquire self-knowledge. However, at this point most art generated is not organically connected to the tools and structures established by the emerging digital culture. Most media content makes use of forms that have their origins in the pre-digital age. In doing so artists and media content creators in general are not addressing the issues that are shaping our society. Thus the evolution of the digital age is left without the strong aesthetic and emotional inputs that art can provide. *It is clear that the fast evolution of technology and its effects on society have produced a discontinuum between development of media technology and media content and consequently a discontinum between our means of acquiring information and our means of acquiring knowledge*. The result is that our society is highly informed, has access to lots of data, but suffers from a lack of deep experiences and true knowledge.

The painting Guernica by Picasso, Fig. 1, is a strong example of art communicating an experience through an analog medium (painting). The horror and agony of war are directly communicated through the visual composition. Picasso can achieve this communication of experience because he handles perspective, shape, color and light as

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masterfully as he handles meaning, semantics, memory, context, form and even sociopolitical history. Thus he is able to create a composition where both the medium and the content obey the same processes and serve the same message. Let us look at some specific examples of this coherent handling of medium, content and message

Fig. 1. Guernica by Picasso; Paintings as means of communicating experiences

Even the printed press, in which Picasso and most of his viewers read about the bombing and show the photos, is part of the composition. The structure of the painting makes anyone looking at the painting feel that an inescapable force coming from the sky is tearing apart the human reality we know and expect. There is no need for the viewer to have any personal previous experience of violence in order to feel the agony and brutality communicated by the painting. What make's Picasso's work even more important is that he is communicating the experience of his time using the forms and media of this time. He was thus allowing people of his time to contemplate their experiences, achieve knowledge of their own world and own lives and influence the evolution of their society. The manipulation of the analog medium of painting to communicate an experience was something that Picasso's audience could directly relate to.

Some of the key points established by this example drive the vision of the AME program. When both the tools (media) and content of a communication are driven by the same goal and with equal mastery then an experience can be successfully communicated and knowledge can be created.

In today's world we create through digital means, images, and sounds and we communicate through digital networked media (like cell phones or the internet). These digital media draw their strength and functionality from computational models. H*owever, the expert creators of digital media technologies (the engineers) are not trained in the creation of content. Similarly the creators of content (the artists) are not trained in the creation and exploration of digital technologies and do not have a fundamental understanding of the computational models driving these technologies.*

AME was formed to address this problem. AME was created by the engineering, arts and science disciplines at Arizona State University. These programs contribute to the AME

graduate education and research program. The education component of this program consists of formalized graduate concentrations within existing degrees that allow faculty and students to combine extensive training in their chosen discipline offered through their home department with hybrid engineering-arts-sciences training offered through AME. We have developed recruitment, retention and placement mechanisms customized for students with such interdisciplinary interests in media and addressing a broad cultural and societal base. The program objective is to produce a new generation of hybrid engineering-arts-science students who will be trained in the integrated development of experiential media systems. The development of such systems can produce major advances in areas such as education, rehabilitation and culture. The development of experiential media systems involves integrated education, training, and research in sensing, information modeling, interactive feedback and experiential construction. Sensing and information modeling expertise resides mostly with engineering whereas feedback and experiential construction knowledge resides mostly with the arts. Expertise for evaluation and validation of these systems reside mostly with psychology, education and sociology. We have structured our research and education activities so as to combine expertise from these disciplines and train hybrid engineer-artists-scientists that have the ability to integrate the four key area of experiential media construction. Our framework allows for methodology found in the sciences to be combined with creativity found in the humanities. It leverages the arts and culture to evolve engineering and science. Consequently two areas formerly considered incompatible are seen coming together for tangible results with broader social impact. Our education model is allowing departments at ASU to step out of their silos, and offer interdisciplinary education without adding significant resources. ASU central administration and the graduate college see the model in development as an exemplar for effective transition from discipline specific to trans-disciplinary education. Our extensive involvement with K-12 organizations and underprivileged communities gives allows children to release their creativity and gives voice to those who might have remained voiceless The graduate education and training mechanisms of AME are based on formally approved interdisciplinary concentrations. That is, we have created hybrid arts, media and engineering concentrations within the graduate degree programs of six of the nine core disciplines of our effort. (Computer Science, Electrical Engineering, Music, Dance, Theater, Visual art). Concentrations in the other three core disciplines (Bioengineering, Psychology, Education) are at the final approval stage. These concentrations require a unique plan of study (POS) that integrates courses and research across disciplines. Two-thirds of the course credits are from discipline-specific courses and one-third are from hybrid media-arts-engineering courses offered through AME. Research and thesis credits are related to work on interdisciplinary experiential media projects from our common research agenda. Degrees are granted by the participating departments and state the AME concentration.

2. The Unifying Arts-Engineering Experiential Media Theme

Lets us look at a biofeedback for rehabilitation example to help us illustrate how integrating engineering and arts can produce an experiential mediated system with important benefits. Patients with lack of proprioception are unable to receive information from their limbs, Fig. 2. They are thus unable to monitor their limbs or maintain internal model of their limbs (they “forget” their limbs). Bioengineering technology has

developed the means to sense and derive in real time most of the important information associated with the movement of a limb (trajectory, 3D placement, velocity, acceleration, synchrony, cyclicity etc). At this point this information can only be presented to the patient (and the therapist) as simultaneous streams of data. The patient can not use this unorganized layers of information to extract and recreate the holistic experience of moving their arm. The combination of bioengineering [11,12] and arts expertise has allowed us to organize this information into a coherent multimodal experience for a propriocetion patient In that project, the relationship of the arm of a patient to a moving target was tracked and presented in a visual display that was synchronized and coordinated with a sound display where each important stream of time-series sensing and derived data (joint velocity, acceleration, synchrony of reversal etc) drove a part (rhythmic or melodic line) of a unified polyphonic composition.

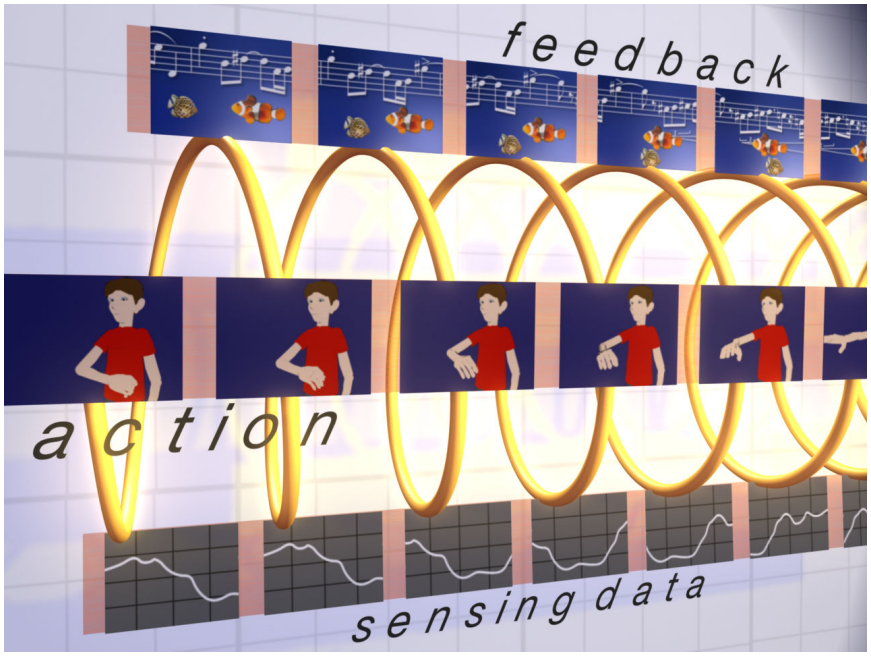

Fig. 2. Integrating engineering and arts; A rehabilitation application

We were thus able to show that allowing the patient to map the experience of moving their arm into an interactive, coherent multimedia experience has the potential of helping them rebuild the internal model of their arm. In other words, we allowed the patient to reacquire knowledge of their arm through a mediated experience. Rehabilitation is only one of the many areas that can benefit from experiential media systems. Our research section shows that the development of such systems can produce major advances in areas such education, rehabilitation, medicine, security, psychology and culture.
The above example shows that the development of experiential media systems involves integrated research in sensing, information modeling, interactive feedback and experiential construction. We have therefore structured our research and education activities to achieve integrated training and development across these four areas. As shown in, sensing and information modeling expertise resides mostly with engineering

whereas feedback and experiential construction knowledge resides mostly with the arts. Expertise for evaluation and validation of these systems reside mostly with psychology, education and sociology.

3. Experiential Media Research

The experiential biofeedback example above was also developed by hybrid researchers: an engineer also trained in music, two artists also trained in computation, and one medical doctor with training in music. It is clear that successful training and research in the creation of experiential media can not be realized simply through cross-disciplinary introduction. Development of experiential media can best be achieved by hybrid engineer-artists-scientists that have the ability for integrated work across sensing, modeling, feedback and experiential construction, Fig. 3.

Currently, most graduate students are left to achieve such integrated training through their own initiative. Experiential media is a non-trivial problem and can only be realized through formalized efforts of interdisciplinary teams that have access to the appropriate research infrastructure and long-term support. Formalized graduate concentrations within existing degrees allow students to combine solid training in their chosen discipline offered through their home department with hybrid engineering-arts-sciences training offered through AME. Students are already enrolled in concentrations and our research in experiential media is advancing rapidly and achieving wide recognition.. Students graduating from our program will have varied employment opportunities ranging from the media, computer and entertainment industries, to biodesign, education and security. Our graduates will leverage the effects of engineering and science on society and help evolve our information society into a society of digitally enabled knowledge.

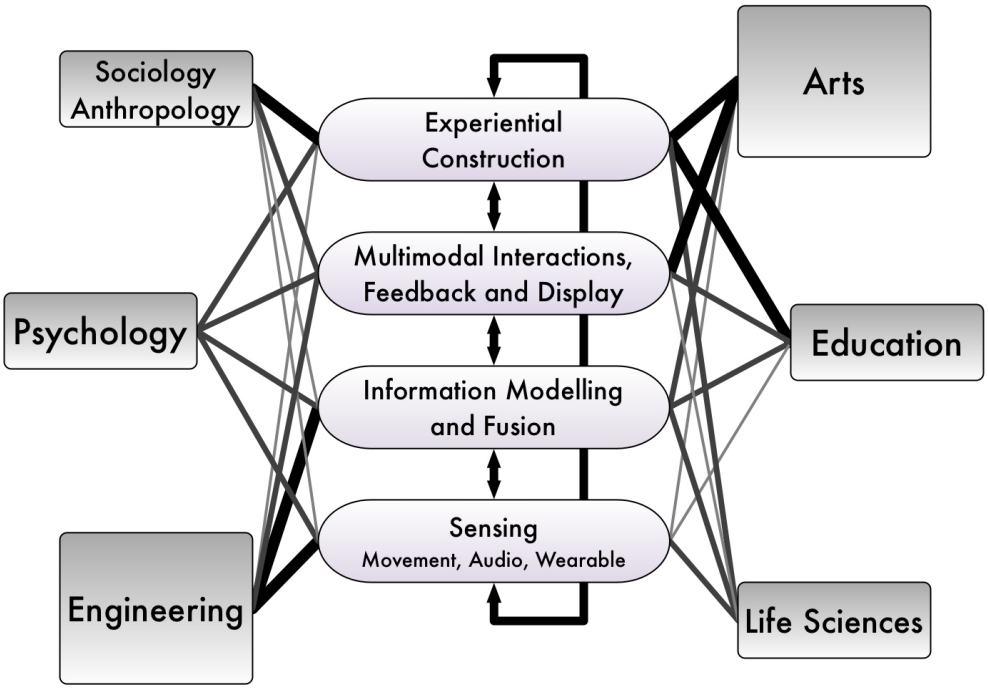

Fig. 3. Disciplines and Research Areas in Experiential Media

4. Relationships of participating disciplines to experiential media construction.

The central research thrust of this program AME is in the development of experiential media systems. This is driven by three social needs, that require integrated trans-disciplinary research and education to be successfully addressed. (a) biofeedback for rehabilitation, (b) experiential learning environments for children (c) development of new interactive art forms [13]. We believe that these complex problems require a tight coupling among bodies of knowledge that are currently fragmented across disciplines. In order for us to solve these experiential construction problems, we need to perform research in three sub-areas in concert, i.e.: – (a) context aware multimodal sensing, (b) information modeling and fusion, (c) multimodal interaction, feedback and display. Each area includes faculty and students with expertise in human behavior and experimental design and analysis. We developed application-specific evaluation methodologies (quantitative as well as qualitative) for evaluating the results of each sub-area. These experts in experimental design will help coordinate the overall methodology and evaluation process.

5. Education and Training

The educational activities of AME are integrally connected to its vision. We believe that training in the creation of experiential media requires: ***Integrated research and education training in a specific discipline combined with hybrid, holistic training in experiential media that is formalized through degree concentrations.*** We have created hybrid arts, media and engineering concentrations within the graduate degree programs of six of the nine core disciplines of our effort. (CSE, EE, Music, Dance, Theater, Visual art). Concentrations in the other three core disciplines (Bioengineering, Psychology, Education) are being formed, Fig. 4. These concentrations require a unique plan of study (POS) that integrates courses and research across disciplines. Two-thirds of the course credits are from discipline-specific courses and one-third are from hybrid media-arts-engineering courses offered through AME. Research and thesis credits are related to work on interdisciplinary experiential media projects from our common research agenda. Degrees are granted by the participating departments and state the AME concentration.

All AME students enroll into PhD programs with AME concentrations in the following five disciplines: EE, Bioengineering, CSE, Psychology, and Education. When enrolling in a concentration a student chooses a hybrid research group to work in. Two of the lead faculty of the group (from different disciplines) become the student's advisors. In consultation with his/her advisors the student chooses the discipline specific courses and the hybrid AME courses that will best fit his/her area of research. Art students enroll into MFA or DMA programs with AME concentrations in the following four disciplines (Music, Dance, Theater, Visual Art). Students from the supporting disciplines (Sociology, Anthropology, Design, Chicana Chicano Studies) will participate in our courses and research but will not enroll in concentrations.

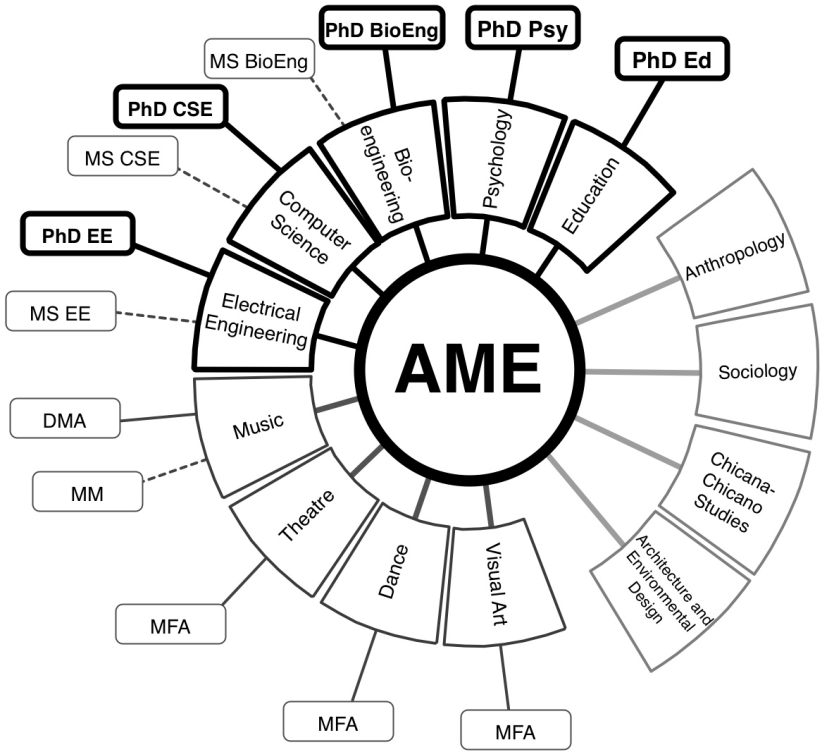

Fig. 4. Education Structures through Degree Concentrations

Hybrid arts-media-engineering courses that are integrally connected to our overarching, holistic, experiential media research agenda. The hybrid courses being offered through AME follow the categories of our research agenda. To cover each subject in an interdisciplinary, holistic manner the courses are co-developed and co-taught by two or three professors representing the primary disciplines associated with the subject. In most cases they are the faculty leading the corresponding research groups. Examples of these hybrid courses include: Under the "Context Aware Multimodal Sensing" category: Motion sensing and analysis, 3D Audio sensing; Under the "Information Modeling and Fusion" category: Cognition and perception of multimodal environments; Under the "Multimodal Interactions, Feedback and Display" category: Multimodal Feedback, Media interfaces; Under the "Experiential construction" category: Computation and communication of experiences, Media education, Interactive Arts. To help students enrolling in the program that might not have prior knowledge across arts and engineering we are also offering hybrid "Introductory courses" such as Signal processing for the arts and Media theory. Many of these courses have already been developed and are being offered through AME. The experiential construction courses serve as integrators of the courses under the sensing, modeling and interaction/display categories.

6. Sample Research Thesis Themes and Projects

Our overall research goal is the development of human-centric multimedia technologies. These are meta-media technologies that allow humans to interact with the computer through sensory activities (gesture, speech, vision). Art is an experiential field. For the development of this infrastructure we conduct research in several inter-related areas listed

below. Each research area will consist of engineering, arts, social science and cognitive science team members.

Motion capture and analysis
This project will create a hybrid motion capture system using optical motion capture, EMG sensors, pressure plates, video, audio, and other hardware sensors to track for parameters such as weight, effort, and intention [1]. The final goal is to use this information as a baseline to create an unencumbered motion capture system using 2D video.

Auditory analysis: sensing and pattern detection
This project involves two problems of auditory analysis: (a) detection and localization of auditory events and b) recognition of speech in complex environments. We plan to perform the analysis using steerable sensors such as microphone arrays. Such analysis, for example, would aid in triggering lighting, sound or projected video based on the sensing and pattern detection of a particular auditory event [2-5].

Spatio-temporal analysis of video,
An alternative to object tracking with electromagnetic devices and translucent markers is video tracking. Video data, obtained from more than one camera, is analyzed to discern valuable information about objects, their location, disposition, movements and trajectory. Individual frames are analyzed for extraction of visual information and frame sequences are compared for displacements and motion extraction [1,9].

Multiple Sensor Processing
Our multiple approaches to sensing will result in an ad-hoc sensor network that involves multiple type and low-cost environmental sensors in a smart space. The objective is to design robust statistical signal processing algorithms to process information in such environments in order to impact various experiencing events. We plan to consider techniques such as sound source localization, tracking and estimating body positions [6,7,8].

Immersive audio and shaping of 3D sound
This project aims to construct an immersive experience by building on existing work on the Head-Related-Transfer-Function (HRTF). The work is based on (a) the determination of the appropriate HRTF given the pose and motion information [6,10] of the person whose auditory experience is to be replicated, and (b) the design of computationally efficient algorithms for audio synthesis.

Immersive visual environments
This project focuses on the creation of an immersive visual environment, to facilitate the transfer of experiences between an artist and the viewer. For example, artists often wish to improvise their performance, based on understanding the immediate experience of the viewer. They want to see and hear what the audience sees and hears; this can be achieved for example, by using head

mounted displays and attached microphones. Challenges include: (a) accurate capture, archival and wireless transmission of such experiences (b) gesture based mechanisms, for selection, and querying of such experiences from the database.

7. Management of AME

AME was formed to facilitate an interdisciplinary, integrated education and research vision. The education panel of AME is responsible for all admission decisions, semester evaluation of students, review of curriculum and funding recommendations. The AME executive committee, made up of faculty who represent the PhD programs that have an AME concentration,

Our hybrid engineering-arts-science approach gives our program an inclusive profile and makes it more attractive to underrepresented populations in engineering and science. We have several high profile recruiting programs at ASU (i.e. Women In Science and Engineering) and national programs that ASU collaborates with (i.e. Western Alliance to Expand Student Opportunities) that will help us achieve diversity in student recruitment. Finally, the Department of Chicana-Chicano Studies is leading our coordinated efforts to recruit Latino students into AME concentrations. For assessment and evaluation of the impact and performance of the program we measure: (1) Student outputs – the number of graduates, years to graduation and where they are placed; (2) Affective outcomes - Surveys of students at entry, mid-program and as they graduate; (3) Surveys of faculty regarding their perceptions of the success of the processes; (4) Products – Quality and quantity of student projects, publication impacts, presentations etc. and most important, (5) quality and quantity of student research products, and (6) extent and scope of faculty collaborations through AME and their productivity. We also have an AME Advisory Board consists of both internal and external experts on the five PhD disciplines. The criteria in selecting the board members include (1) reputation in their expertise fields; (2) experience in interdisciplinary research and education; and/or (3) education/research assessment. The board will meet once a year to visit AME program for annual evaluation in addition to communications through meetings, emails and phone conversations. The two founding colleges and the university are supporting AME through dedicated faculty lines, staff positions, facilities and seed research funds.

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