Jim: A Platform for Affective AI in an Interdisciplinary Setting

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Abstract

We report on Jim, an inexpensive student designed platform for embodied affective AI. The project brings together students from backgrounds in computer science, physics, engineering, and Digital Media Arts (DMA) in an informal educational setting. The platform will be used in AI courses and autism treatment studies.

Introduction and Background

Direct, high fidelity mimicry of human gestural emotion is challenging and expensive. Kismet (Breazeal and Scassellati, 1999) and Face (http://www.faceteam.it/) provide a means to explore affect and design affectively interactive systems, but are outside of the technical and financial reach of the typical undergraduate team. Puppeteers have long employed simple, broad stroke approximations of human gestures to elicit strong emotional responses. The Jim project takes advantage of the lessons of puppetry and the low-cost of Lego Mindstorms to make aspects of embodied affective AI accessible to undergraduates.

While operation in the affective regime with Lego is new, enabling substantive AI with the platform is not (Lanighan et.al 2011, Klassner, Peyton-Jones, and Lehmer 2012.), nor is the use of Lego robotics as a classroom tool (Klassner and Mcnally 2007, Panadero, Román, and Kloos 2010, Sklar, Parsons and Azhar 2007). Here we explore an option for utilizing Lego in the affective domain using custom controllers and MIDI communication.

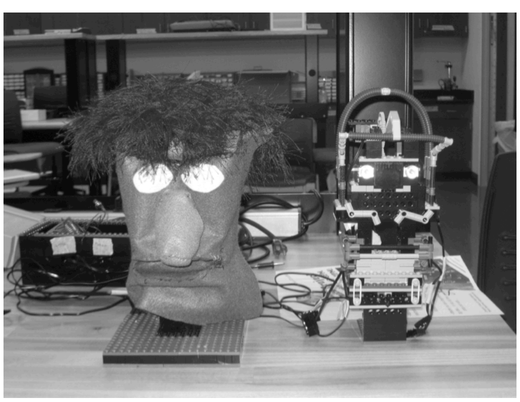

Figure 1: The avatar (left) and a prototype without skin (right).

The Jim platform is, in essence, a robotic Muppet head. It has the capability for rudimentary speech, gestural emotional output, and open-ended control interfacing via MIDI. As a result of the Jim project, physics and computer science students have gained experience in complex tasks which typically fall outside of our curricula, or are only touched upon in higher level or elective courses: custom design and programming of microprocessor electronics, MIDI interface programming, coordination of multi-process software, coordinated hardware and software robotic design, and affective human-machine interaction.

Jim consists of three major subsystems, with accompanying software: a mechanical avatar, a custom electronic motor control interface, and a laptop computer. The design is fundamentally modular, with communication between the laptop and motor controller handled via MIDI interface, and the avatar driven by DC controller outputs.

The Systems

The Jim avatar, figure 1, has three degrees of motional freedom: a single eyebrow, movable lower jaw, and tipping at the neck, as well as two lighted eyes for additional expressive capability. The avatar is primarily constructed using Lego Mindstorms parts and motors. Mindstorms was selected for three criteria: it provides for rapid prototyping and modification with no time expenditure for parts manufacture, it consists of a range of stock parts to achieve a wide array of structural and mechanical systems, and it is readily available through a preexisting supply. RCX was selected over NXT for the added benefit that the RCX motors are spatially compact DC devices, whereas NXT motors use coded and pulsed signal transfers. The DC motor format proved helpful in controller design. We replaced the standard RCX control bricks with a custom controller.

The underlying physical structure of Jim is visible in the right portion of figure 1. For stability the jaw is operated by two motors acting in parallel. The lower jaw is also attached to the upper by elastic bands. Although this was initially intended to be a mechanism for allowing the robot's mouth to close reliably, it was discovered that the elastic could be utilized in conjunction with the motors to create a shuddering effect or quivering lower lip, which is useful in displaying intense emotions, notably sadness and anger.

The face of the robot currently consists of a felt overlay, with an attached cotton-stuffed felt nose. The hair and eyebrows are made of strips of fake fur. The felt provides an acceptable visual surface with limited mobility. We are upgrading the face to fleece to improve flexibility.

The decision to replace the native RCX controllers with a custom design serves multiple pedagogical roles; it reinforces electronics curriculum for physics students, enables the use of MIDI protocol, and allows output channels in excess of the RCX limit of three. The control interface was designed and constructed by as a physics senior thesis project. It utilizes a dual voltage power supply, PIC microprocessors, and component electronics to take an input MIDI signal and output controlled voltages to the avatar. PIC microprocessors were selected both for their familiarity to our students and wide use in commercial electronics.

The most important aspect of the controller is the MIDI input. MIDI is convenient as a communication encoder, as it is compact and carries time-stamped, sequenced messages including commands for On, Off, and Velocity (intensity). The output state of the avatar maps directly onto musical notes. Turning on a motor (or light) is equivalent to striking the note key, with a louder note corresponding to a faster motor speed. Duration of the motor activation is equivalent to the duration of the musical note. Selecting an emotional state transition for the avatar is a series of motor commands, which can be thought of as a sequence of ons and offs at varied motor speeds, in effect a brief musical composition. MIDI can be used to play Jim's emotional outputs as sequenced tracks; transitions between emotional states are different sequences.

An additional benefit of MIDI interfacing is that any MIDI capable device can be substituted for the laptop controller to engage the avatar. For example, students have utilized a standard musical keyboard to demonstrate prototypes of Jim and to determine the appropriate sequencing for emotional transitions. Pedagogically, the use of MIDI serves as a practical introduction to standards compliance. Lastly, our working group has evolved from a musical electronics group, with many members both familiar with MIDI and pursuing career goals related to audio engineering. For them, working with MIDI is valuable.

The control laptop is not a necessary component for use of the Jim avatar. In fact, any MIDI capable device can drive the control interface. However, the computer is required for any higher level AI routines: vision, speech, facial recognition, etc. We used a windows XP laptop with a USB to MIDI output adapter cable. Two major software components currently exist: the emotion control routine which communicates with the control interface, and a script parser which drives a storytelling mode.

The emotional control software for Jim is designed to allow for modular insertion into larger-scale AI projects. At core, it is driven by the calls to a state change function. The function takes two parameters: the current emotional state and the target state. For each parameter pair, the appropriate timed MIDI sequence is transmitted via USB to the control box. The list of states currently includes standard emotions (e.g. happy, sad) and an affect-free state.

Transition functions are used because the movement sequence needed to reach the happy state from the angry state is different than that used to reach the happy state from the neutral state. A transition from angry to happy requires Jim to raise his eyebrow, whereas a transition from neutral to happy requires no movement of the eyebrow. With N emotive states, there are N^2-N possible transitions, which can be thought of as an emotional matrix.

The choice of a modular transition function allows for easy adaptation of the specifics of Jim's affective response. Currently, there is student interest in designing a fully onscreen animated avatar for Jim. Implementation will require replacing the MIDI sequences with equivalent play commands for pre-designed animation, while leaving the main interface intact. This flexibility also allows for adaptation to new hardware, alternate avatars, the reimplementation of an emotion using the current avatar, such as by adding levels of emotion to mimic intensity variation.

Jim is scheduled for deployment in the classroom as a platform for AI lab exercises in spring 2015. The Institute of Autism Research at Canisius College is likewise considering adopting Jim as a training device for use in teaching high functioning autistic children to read and respond to emotional cues. Additional collaborations using Jim for student projects in sociology, DMA, and physics are under consideration. Two undergraduate students are working on upgrades to Jim, and as many as three more have expressed interest in joining the group. Jim is a viable tool for attracting undergraduate students to work in AI and robotics, as well as for use in classroom AI projects.

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