Using a Gestural Interface Toolkit for Tactile Input to a Dynamic Virtual Space

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Abstract
In this paper, we describe the development of a gesture interface toolkit that has been applied to an application of tactile gesture recognition within an artificial life environment. The goal is to design a gestural semantics of caress, in which qualitative attributes of gesture are expressed as a function of tactility. A touch–sensitive tablet capable of detecting multiple simultaneous contacts was used to provide a source of tactile gestures (stroking, pressing, tapping, wrapping, spreading, pinching, nudging) which were then interpreted by the software as events to be sent to the active creature in the environment. Participants could observe the creature reactions within a three–dimensional immersive display system.

Keywords
gestural analysis, tactile input, gesture recognition, gesture toolkit, immersive environment, Laban Effort-Shape analysis, movement analysis, gesture-based interface, whole hand input, CAVE, Max/MSP, Tactex MTC

Introduction
The Gestural Interface Toolkit (GIT) is an Application Programming Interface (API) for developing responsive systems that require access to tactile feedback devices. The objective of the toolkit is to provide uniform and consistent handling of several classes of input and output, and to support complex analysis and recognition algorithms directly [3]. In this initial implementation of the GIT, Tactex Controls Inc. [7] pressure-sensitive material called Smart Fabric, is being used. This optical fibre array has been packaged into a device called the Multi-Touch Controller (MTC). Data from the device is in the form of a continuous stream of pressure values, which can then be used to detect multiple simultaneous contact points or touches [10]. The sampling rate for the device is comparable to video frame rates, so that the appearance of smooth, instant response is achievable.

Our goal of developing a gestural semantics of caress requires the development of qualitative models for data flow and data–architecture and the development of semantics for gesture that refines the extension of tactility [2]. Although not yet implemented, new devices, such as six–degrees–of–freedom (6DOF) tracking devices or 6DOF trackballs, biological (heart–rate, galvanic response, brainwave) sensors and as well as sound, graphical and other tactile sensors can be integrated into the Toolkit to provide new modes of interaction [6]. As an infrastructure, the Toolkit has mechanisms to support remote attachment of devices and collaboration between heterogeneous systems, via support of messages through TCP/IP channels.

An existing artificial–life environment was selected as a test–bed for the innovative use of tactile gestural input [4,5]. The environment consists of a community of creatures that evolve under the guidance of a genetic algorithm. There is also a mechanism by which external agents (web browsers or direct keyboard input) can influence the behaviour of the creatures. New "verbs" were added to the system to accommodate the expected behaviours from the Toolkit, which was subsequently adapted to provide a mapping from the detected gestures to this mechanism.

Implementation
Implementation of qualitative semantics is based upon definitions from Laban Effort–Shape Analysis [1] which defines movement efforts based on Time, Space, Weight and Flow characteristics. In Laban Effort–Shape qualitative characteristics can be aggregated and expressed as 'drives' and 'states'. The pressure data from the MTC device is mapped into a rectangular coordinate space and then filtered and processed using techniques from image processing and recognition. The software for this process is an image processing tool [8] that is an extension of the Max/MSP programming environment [9]. Parameters are extracted from this raw image data, which are used for preliminary gesture recognition. These measured parameters are

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interpreted in terms of subjective linguistic terms, which lead to the effort-shape model. Gesture divisions are not extracted at this stage, and the more data-intensive pathways are not determined, as the goal is not to match previously performed gestures but, rather, to obtain the subjective quality of movement represented by caresses on the MTC device.

In Laban effort–shape movement analysis, the attributes of Time, Space, Weight and Flow are defined as follows: Time is represented on a Quick/Sustained continuum, Space on a Direct/Indirect continuum, Weight on a Light/Strong continuum and Flow on a Free/Bound continuum. Information is extracted from the device in various categories, differentiated by the level of calculation required to extract them. These categories are direct parameters (Location, Size, Start Time, Stop Time, Intensity and Number), which are measurements from the device, calculated parameters, and inferred parameters. Indirect parameters (Duration, Speed, Direction, Direction Change) are those that are calculated from the direct parameters. All of these parameters are quantified into three or four levels of activity. For instance, intensity is quantified into values between light and strong, which map to the Laban *weight* effort. The quantified value is subjective in nature and corrected via threshold adjustments based on experience over time.

Results

The combination of the artificial–life system with the GIT created a very responsive environment in which natural gestures (the petting of the creatures) resulted in immediate and relevant responses. This gave a feeling of connection and familiarity to the experience, despite the extremely abstract representations used for the artificial life forms.

The integration of the GIT with the application was successfully mapped, as the gestures could be recognized in real–time and quickly converted into the commands or "verbs" needed for the environment. By physically separating the gesture processing from the application, it was possible to easily explore alternative solutions for the gesture mapping and interpretation.

Implications to HCI

Gestures appear to provide a very natural means to interact with an evolving environment such as this artificial life simulation. Rather than aggressively moving objects from point to point, pushing buttons or grasping, as is often done in virtual reality (VR) systems, the gestures used can be gentler, less invasive, and with a greater dynamic range. This permits the system to develop with perturbations that are proportional to the forces applied. As well, the nature of the gestures ("petting" or "stroking") is much closer to the way children interact with animals. They don't attempt to dominate other creatures – they express interest, affection and wonder. These modes of interaction are not exhibited in such domains as video gaming. The MTC device is a viable alternative to conventional touch surfaces, with sufficient sensitivity and responsiveness for use in hand gesture recognition.

Future work

The GIT primarily needs to be enhanced in three directions:

1) Further work on the gestural language, with provision for handling gestural phrases or time–dependent inputs,
2) Support for more devices and characterizing its behaviour with multiple devices, possibly networked and
3) Reduction of the size of the system(s) required to implement the GIT, so that a wearable version can be developed

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