Connexus: An Evocative Interface

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Connexus *– A binding together; a connected whole. A connection, tie, or link between individuals or groups. (OED)*

ABSTRACT
Human communication and interaction is comprised of a wide range of verbal and non-verbal cues. Further adoption of novel tele-communication methods such as email, chat, instant messaging (IM), mobile phone SMS text messaging, and videoconferencing; have augmented our mediated interaction abilities. However, a significant (and important) amount of human expression and interaction information is never captured, transmitted, or expressed with current computer mediated communication (CMC) tools. We also lack ambient methods of maintaining contact when not co-located with family and friends. Evocative Interfaces is a new research effort aimed at the study of non-verbal human cues, their intent, motion, meaning, subtleties, and importance in communication. In this paper we address issues involved in the design, construction, and evaluation of Connexus, one such Evocative Interface.

Keywords
Ambient telepresence, instant messaging, SMS.

INTRODUCTION
Fundamentally, humans communicate and interact among each other in rich and complex ways. When co-located we are able to trade off between a wide range of cues, both verbal and non-verbal.

However, when we examine our mediated communication tools for establishing communication when **not** co-located, we quickly see our communication channels restricted to primarily verbal channels such as text and speech. While there is emotional augmentation such as emoticons for text messaging and tambre, pitch, intensity, and inflection for voice calls, there is a need to explore non-verbal interfaces between non co-located people.

Our research in Evocative Interfaces is focused on developing novel mediated communication tools to explore methods of non-disruptive interaction when not co-located. People send such messages quickly, efficiently, and often without being distracted from their current task. These signals are also typically very personal in nature, involving touching and other forms of physical contact.

Evocative Interfaces should allow for easily establishing and maintaining emotional ambient connections. Our observations of co-located human interactions led us to the following design criteria for Evocative Interfaces: (1) non-disruptive I/O (*i.e.* ambient), (2) always on, (3) personal association to the communication artifact [1],[1] (4) support for non-verbal communication, and (5) attempt to provide some level of exchange of human emotions (*i.e.* emotional interface).

This paper explores the challenges, successes, and failures around designing one such body worn personal Evocative Interface called a Connexus.

MOTIVATION
Communication and interaction is a vital element of human life. It manifests itself in two primary forms: verbal and non-verbal. Most verbal communication is obvious such as face-to-face conversations, email, phone calls, and text chats. Non-verbal communication is often more subtle and hence difficult to detect and evaluate. Examples include facial expressions, posture, gaze, body positioning, gesture, physical contact, body motion, smell, and even silence.

Human evolutionary history has provided us with an innate skill to efficiently encode transmit, receive, and decode complex non-verbal cues among other co-located humans. An interesting element of many of these communication signals is that both their transmission and reception is a form of ambient communication. That is, typically neither individual involved in the communication exchange is significantly distracted from their current task. This is unlike verbal communication which typically requires foreground user attention to conduct.

[1] Peter Desmet's recent book, *Designing Emotions*, discusses the interplay of product design and emotions elicited by such artifacts.

Initial Observations

We initiated our exploration of this research area by watching non-verbal interactions of co-located people who had prior established relationships [2, 3].[2] These observations primarily occurred at public markets, shopping districts, parks, sporting events, and on public transportation. We are in the processes of formalizing these observations but our preliminary results point to a fundamental human urge to maintain some open communication channel at almost all times when co-located.

For example, we repeatedly observed couples, friends, and families that maintained some form of physical touch with each other even when their attention was draw to another task or they were directly involved in a conversation with another person. This contact did not always manifest itself as direct handholding but rather more subtle touching of fingers, hands, arms, legs, backs, and shoulders.

We also noted a high degree of reaching out with simple hand and body gestures to connect to the other individual. Often we observed directed glancing. Rather than to establish direct eye contact it occurred more often for simply checking on the other individual's location, activities, and attention. This appeared to serve as a simple awareness monitor of the other individual's state.

What's important to note is that while we observed individuals engaging these non-verbal cues to acquire some awareness of the other co-located person's status, they almost never acted on it. That is, there was sufficient satisfaction in simply gaining some knowledge of the other person's state of being. We speculate that this activity serves some essential human need to experience a glimpse into another person's state of being as a bonding element of the relationship.

The bottom line is that there is a fundamental human need to maintain such ambient "connections" with others even when co-located. Furthermore, people are extremely adept at conducting interactions with such non-verbal cues. But do current CMC tools support any of this style of human contact?

Generation Txt

Quick "glance" style messages are currently all the rage, especially in the teen market segment. Currently, 73% of teenagers 12-17 are online in the USA, 13 million use instant messaging (IM), and 20% consider IM their primary means of maintaining contact with friends [4]. Overseas in Asia and Europe the numbers are even larger, particularly on mobile phones using Short Messaging Service (SMS), i-mode, and similar text messaging services.

This communication revolution can draw interesting parallels from the introduction of wireless pagers. The initial usage model was that a person would send their phone number to an individual's pager; the recipient would dial the displayed number on a phone and establish the connection. What evolved was an entirely different usage model. In fact a new cultural vocabulary of numerical messages arose. For example, users defined new encodings such as, "When I send '1-2-3', that means 'feed the dog', '4-5-6' means 'thinking of you'."

Since these devices (pagers and now mobile phones) are always on, always connected systems, their usage model is both personal and ambient. One teen expressed, "I carry it around all the time, even in the house.…It's like my little baby, I couldn't live without my mobile, I bring it into the bathroom with me." Similarly, another couple on separate continents (and hence time zones) used SMS to send awareness messages to each other with no intention of engaging in dialogue. "When I get up in the morning I send her an SMS message that I'm 'Now making coffee' just to let her know what I'm doing….I guess I want her to be able to imagine me in the kitchen making coffee."

In fact almost everyone has been in a phone conversation with a friend or loved one with nothing to say, yet will opt to hold the line open in silence rather than simply terminate the call. There is some intangible value to holding such a connection open without any direct transmission between the two distant individuals.

From earlier we had observed clear examples of how humans used physical and gestural non-verbal cues to establish and communicate similar messages when co-located. The research question for us was to explore how humans would establish and maintain such simple, ambient, non-verbal, communication cues when **not** co-located. What would such a non-text and voice based interaction tools look like? What would it sense? Express? How would a user interface to it? Even more importantly perhaps is whether such simplified, distilled communication cues are able to maintain a useful meaning even when extracted away from the context of whole body interactions from which they potentially relate?

RELATED RESEARCH

Designing human-human interaction metaphors away from text and speech into simple, physical, ambient communication tools have lead to a wealth of interesting work in this area. We desired to lean and guide our research by drawing from much of this related work.

Strong and Gaver initiated exploration of devices that supporting implicit, personal, and expressive communication as opposed to explicit, goal-oriented communication typically found in CSCW research [5]. Their work at the Royal College of Art has provided

[2] We were less interested in non-verbal communication between strangers. While we readily admit that such interactions are extremely interesting, we wanted to focus on a wider range of permissible non-verbal cues. Studies have shown that many non-verbal cues manifest themselves as personal and are more easily exchanged between individuals with pre-established relationships.

valuable inspiration for this project. Researchers have also addressed the "glancing" metaphor and its parallel in CMC with the exploration of MediaSpaces and more specifically, Portals [6].

Various physical interfaces have enabled remote individuals to arm wrestle [7], blow kisses [8], transmit hugs [9], exchange simple touching [10-12], and send gestures [13, 14]. Others have provided ambient telepresence through existing physical artifacts [15, 16].

Similarly, there has been a tremendous amount of sociological studies of mobile phone usage and in particular SMS messaging [17, 18]. Some of the apparently unique phenomena occurring in the rapid expansion of these new communication modes can be observed in previous instructions of interaction technologies [19, 20].

Finally, a recent, and closely related messaging tool, is Emoji. Emoji are special pictographs (not unlike hieroglyphics) used on i-mode enabled phones when exchanging simple messages. What's interesting is that a simple series of pictures is used to send a message rather than text or voice (see Figures 1 and 2).

Since our Connexus device is worn, it also draws from research in the field of wearable computers and a user's personal interaction with body based interfaces [21-23].

Figure 1: Emoji for "My dog peed on the flowers; Mom's gonna kill me."

Figure 2: Emoji for "Here's an idea! Let's go listen to jazz at 8pm."

CONNEXUS

An important part of our research was the construction and evaluation of at least one such Evocative Interface. The physical system we designed is named a Connexus. A Connexus is a small, simple, body worn personal object augmented with simple sensing, actuation, and *ad hoc* networking support.

The focus was to design a system that would allow exploration of how humans would communicate when not co-located without the use of text or speech. Our design, therefore, intentionally avoided text or text-like modalities as input or output.

Another reason for avoiding text and speech is that we wanted the device to enable ambient style personal communication between people. Speech and voice sounds were too disruptive to others and lacked the privacy of a personal message when heard by those nearby. We avoided text both to move towards more figurative interactions and to avoid the disruption of entering literal characters though a keypad.

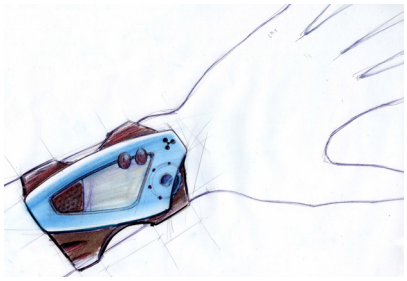


Figure 3: One of several Connexus Concept Drawings

The basic idea is to create a small connection of sensors to capture information from one end and transmit them to the other end for expression using various actuators. Rather than creating a fixed mapping we were more interested in allowing the users to explore the interaction space.

The overall design is based on research into small wireless Smart Dust systems [24]. In fact the prototype is constructed around a Mote [25] platform running TinyOS [26].

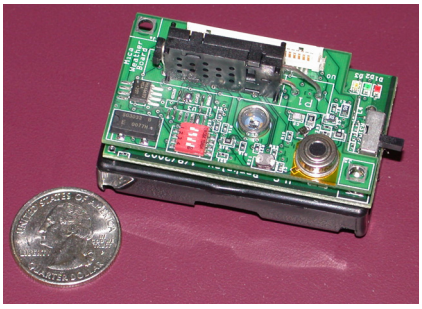
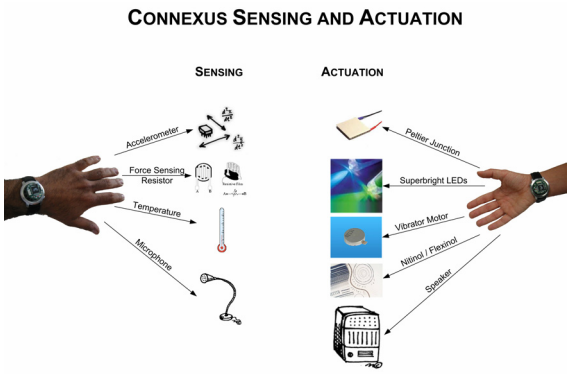


Figure 4: A wireless Mote with onboard sensors

SENSING

Rather than overwhelming the user with sensing we chose a few reasonable sensing modes that were readily available on the Motes with the addition of a few simple components. While we admit that we may not have chosen optimal sensing modes, we were more interested in moving towards a prototype that we could begin evaluation on rather than exhaustively iterating through sensing technologies.



Accelerometer

MEMS based accelerometers are inexpensive, robust, and provide rich data as an input source. For a wrist worn Connexus, the accelerometer allows detection of rough hand orientation, crude gesture measurement, and tapping upon the Connexus. We are hoping to examine simple activity detection such as sitting, walking, and standing. One of the difficult challenges, as with all of the sensors, is the buffering of data and filtering to allow adequate detection of signals. The reliability and low bandwidth (20kbs) of the radio link prohibit real time sensor measurement over the network. This is not a significant problem since the latency introduced by the GSM network far exceeds such sensing delays (see Connexus Architecture section).

Force Sensing Display

Force sensing resistors provide pressure detection over a low resolution surface array on the top of the Connexus. This allows for simple touching to be sensed. By time stamping the sensed data, rich signals such as a user swirling their finger along the surface of the Connexus can be detected.

Temperature

Temperature sensors are both inexpensive and easy to integrate into the Connexus design. We are experimenting with sensing not just ambient environment temperature but the difference in temperature between the air and skin as well as the air and top surface of the Connexus.

Microphone (Not What You Think)

Sensing ambient sounds near and individual is a planned input for the next version of the Connexus. The sensing is not designed to record voice or provide audio sensing resolution to detect individual speech or even to identify a speaker. The idea is to provide an extremely low resolution audio awareness tool between two individuals. The idea is that the microphone would allow the paired Connexus user to infer such things as, "He's talking to someone" or "She's in the car" or "Sounds like it's quiet around him now. Maybe he's working or resting." There are a significant amount of privacy issues that arise when introducing such an input so its inclusion is undergoing a more careful study.

ACTUATION

We chose a number of novel (*i.e.* non audio and text based) output modes for the Connexus. Similar to the sensing, we simply chose a few reasonable actuators to provide a sufficiently interesting set of output modes. The mapping between the inputs and outputs of the paired Connexus devices is neither literal (*i.e.* sensed temperature increase maps to heat output increase) nor statically defined (see Sensing/Actuation Mapping section).

Peltier Junction

When electrical current is applied to a thermocouple, a temperature difference is created with one side of the thermocouple being hotter than room temperature, and the other being cooler. Peltier Junctions (Peltiers for short) contain no moving parts, are compact, noiseless, operate in any orientation, and do not require the use of liquids, gases, or refrigerants. This makes them well suited as a temperature output device when in contact with skin.

Superbright LEDs

While the technology is simple and "gadgety" we wanted to move away from any form of pixilated display. We especially wanted any visible display to be completely unable to render literal text of any kind. However, we were acutely aware that people have innate responses to illumination and colored light. The superbright LEDs mimic more of a mood ring like effect. That is, there is no rapid flashing or flickering of color.

Vibration Motor

Simple vibrations are easily and privately felt though skin contact. Various vibration patterns and duty cycles provide a number of output possibilities for the Connexus. We used simple flat pancake vibration motors to induce vibrating output.

Nitinol / Flexinol

Nitinol is a Nickel-titanium filament that contracts when electrically powered. They are often used in robotic applications where they are commonly referred to as shape memory alloys or "muscle wire". The advantage is that they can typically exert large forces, as compact, and are simple to actuate. Their drawback is that to return to their original position can take hundreds of milliseconds as they cool. For the Connexus project we prefer to have a slow actuation device which is better suited to our ambient theme. Flexinol is a simple variant for applications requiring a large number of repetitive cycles on the filaments. For the Connexus, Flexinol allows for wrist based slight constriction mimicking touching/holding. Due to its small size it can also be used for a small array of pressure outputs at the bottom of the device.

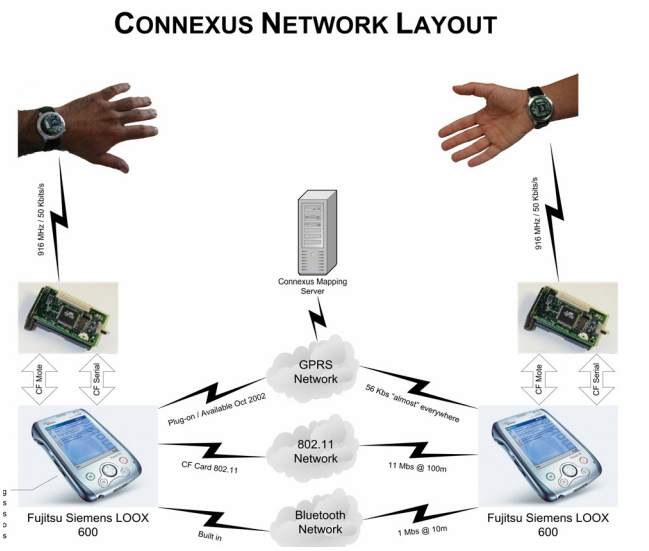
Speaker (Not What You Think)

As discussed in the sensing section of microphones, the idea is not to allow direct audio conversations to occur nor to listen in to another's direct words and actions. Instead the plan is to work at incorporating a low level audio

output. This allows for low frequency (and low quality) output either directly relating to the sensing microphone or tied to another sensor for more figurative output mapping.

CONNEXUS ARCHITECTURE

Of prime importance is to build a system usable outside of our laboratory. The Connexus is composed of a simple Mote board used to communicate with the various sensors and actuators onboard the device. These Motes are wirelessly connected to a gateway compact flash Mote inserted into a small PocketPC device. The PocketPC directly communicates, wirelessly with the wrist worn Mote based Connexus (see figure on next page).



Everywhere Real Evaluation

Each pair of Connexus units communicates with each other through one of three modes. The first is in our lab through a direct Bluetooth connection. The connection is established though the PocketPC's which each contain internal Bluetooth hardware. This allows for range of only up to 15m.

A better mode is the use of public DHCP enabled 802.11b wireless networks. These connections can occur whenever an individual is within range of a wireless access point. However, this is a major disadvantage as we want to allow interactions when outside buildings and away from 802.11b wireless networks.

Generalize Packet Radio Service (GPRS) allows always on connection states for mobile data transmissions. Data rates can be as fast as 115 kbps using existing GSM base station infrastructure. The PocketPC has an optional extension allowing for direct integration onto such GSM wireless mobile networks. This allows Connexus users to maintain connections at almost any location such as in buildings, at baseball games, in a mall, on a bus, or sunning at the park.

Sensing/Actuation Mapping

The network layout figure contains a "Connexus Mapping Server" in the architectural drawing. The idea is that while we do have beliefs on how such sensing/actuation mapping may be desired to be laid out, it is more interesting to allow the community of users the freedom to design their own I/O mappings. This open flexibility in the interface mapping design is intentional to allow for a richer exploration of user desires during the evaluation phase of the project.

EVALUATION

This research is currently ongoing and has not reached a formal evaluation phase. This paper is being submitted to the workshop to gain feedback and help generate discussion about such systems. It is hoped that some level of formal evaluation will be available at the time of the workshop in a more recent version of this document. For now this paper is more or a position paper on some ongoing research related to *ad hoc* communications and collaboration.

PRIVACY

The Evocative Interfaces described in this paper touch heavily on issues of privacy. While initial prototypes and usage studies are design to be conducted between individuals with strongly established relationships where privacy is less of a concern, we are not ignorant to the importance of privacy when designing such communication systems. We are in the process of formally addressing privacy concerns in this research and will include them in subsequent releases of this document.

RESULTS

This paper represents work in progress and results will be forthcoming at a later time. We are hoping to provide some level of initial results from early studies by the workshop.

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