Giveaway Wireless Sensors for Large-Group Interaction

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ABSTRACT
We have developed a small, handheld or wearable, wireless motion sensor that sends out a short RF pulse whenever it is jerked. The hardware is minimal, as it mainly includes only a piezoelectric foil accelerometer, a CMOS timer, and a single-transistor 300 MHz RF transmitter. As such, the onboard battery should last for many years, and the cost is low enough (well under US $1. in large quantity) to be given away with a ticket to an event, enabling it to be used to allow individuals to contribute to a large-group, real-time interaction. We discuss results from experiments using this device to explore collaborative music control, and touch on other applications.

Author Keywords
Motion sensor, large group interaction, musical interface, featherweight wireless sensor, low-power wireless sensor.

ACM Classification Keywords
H.5.3 Group and Organization Interfaces, H.5.5 Sound and Music Computing.

INTRODUCTION

A classic challenge in interactive entertainment is creating environments that reflect and react to the collective activity of groups with tens, hundreds, or even thousands of participants. Most previous work in this area has employed video tracking of handheld, color-coded reflective targets [1] or general audience motion [2]. Some recent projects involve wireless transmission of biological signals, e.g., providing media feedback in an attempt to synchronize heartbeats [3]. Wireless multiplayer gaming is also growing very popular on cellphones [4] and PDA's [5]. These techniques, although appropriate for some applications, are limited for others, e.g., real-time feedback for kinetic group activity, such as in dance clubs - video needs a clear line-of-sight, biological signals can be slow and nondeterministic, PDA's and cellphones are complex, slow and expensive.

IMPLEMENTATION

We have designed a simple handheld sensor for large-group kinetic interaction that sends a wireless pulse when jerked with more than 2.5 G's of force. The hardware, shown in Figure 1, is minimal [6], as it mainly includes only a cantilevered piezoelectric foil accelerometer, a CMOS timer, and a single-transistor, 300 MHz RF transmitter. As the current drain is extremely low and a 100 ms deadtimer prevents multipulsing, the onboard battery should last for 3-4 years of normal use (assuming 1 event/week). The cost is low enough (well under US$ 1. in large quantity) to be given away with a ticket to an event, enabling individuals to use it to contribute to a real-time, large-group interaction. As the RF pulses are only 50 µs long (no ID code is sent) and the RF transmission radius is limited to circa 10 meters, the probability of collision is very low, even when people try to synchronize [6]. Likewise, the limited reception radius enables the content to be zoned locally, with multiple receivers covering a large venue as needed.

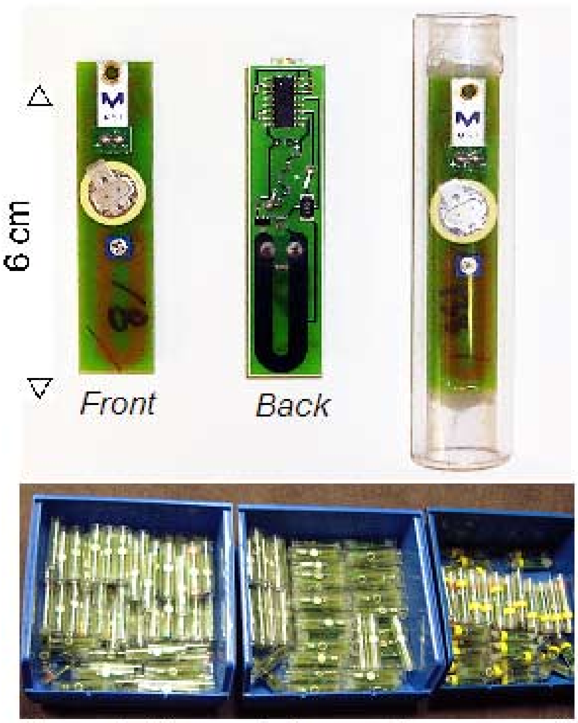

Figure 1: Cheap wireless motion sensors & batch of 300

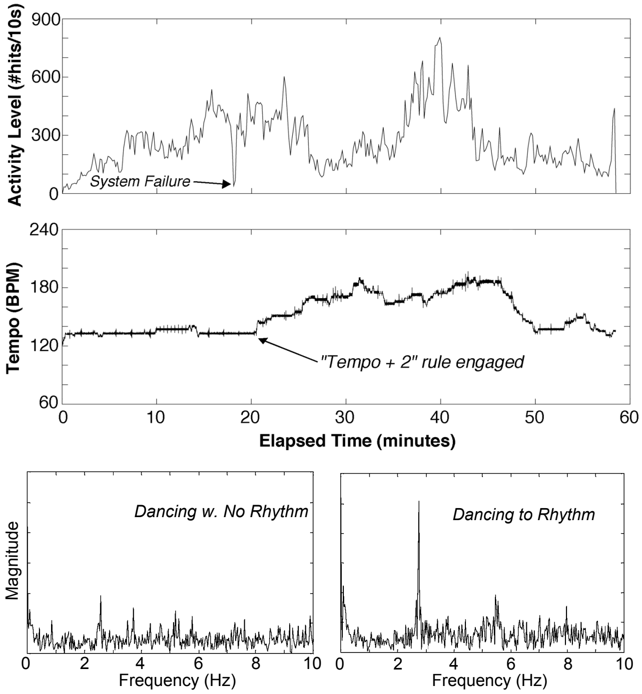

Figure 2: Signals for group event (top) and FFT test (bottom)

SIGNAL ANALYSIS AND IMPLEMENTATION

A base-station interface has been developed [6] that counts the number of pulses arriving at a set of receivers across a 2 ms interval. This data is analyzed in real-time to derive a set of features, including activity levels (the number of hits arriving across different time intervals), significant events (more than a certain number of hits arriving simultaneously), and average tempo (derived from a FFT or cross-correlation on a low-pass-filtered data frame). Dancers hold one sensor in each hand. The lower plots in Figure 2 shows how a Fourier Transform on 30 seconds of sensor data exhibits a dominant peak that resolves the dancers' 160 BPM tempo, vs. a flat spectrum for dance to non-rhythmic music. These features are then mapped onto generated music using a set of rules [6] (e.g., the music becomes more complex with increasing activity, the tempo produced is set to the detected tempo plus 2 beats-per-minute, significant events with many closely-timed pulses produce a corresponding audio effect), allowing the dancers to dictate their music. We have run this system at several "interactive raves" held at MIT, with up to 200 sensors distributed (Fig. 1); dancers held one in each hand. Fig. 2 shows data from an hour at one such event. Aside from a transient system failure near 20 minutes, the detected activity level shows two zones of kinetic intensity, with the peak near 40 minutes more pronounced. This corresponded to activation of the "Tempo+2" rule, where the participants danced increasingly faster to a tempo that always led their current pace. Although the musical interaction mapping could benefit from additional development, user surveys [6] conducted after this event indicated that dancers tended to feel control over the music, especially when contrasted to other events where the mapping was static or random.

CONCLUSIONS AND OTHER APPLICATIONS

Although our musical content produced individual sounds with each arriving pulse at low activity levels, this direct link was abandoned in favor of mapping to the higher-level features introduced above as activity increased. Since it's well known that large groups of humans school well through prompt audio feedback (ranging from an orchestra through simple clapping [7]), it would be interesting to better exploit this tendency in future mappings that follow individual activity further towards constructing spontaneous structure. Future hardware could transmit signals with a much sharper edge, allowing the sensor to be better located with UltraWideBand (UWB) techniques [8] and enabling content to better exploit zoning. These sensors appeal to other entertainment venues - e.g., in interactive gaming or electronic "cheering" for people at sports stadiums and large outdoor events. They are also appropriate for different niches where low-cost, high-longevity sensing is called for - for example, instrumenting a delivery package to trigger an alert if it falls in a truck, or scattering sensors around a smart house to track the activity of a sick or elderly occupant [9].

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