# Possibilities for the Digital Baton as a General-Purpose Gestural Interface

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## ABSTRACT
This paper describes issues and results from the design and use of the Digital Baton, a new interface for real-time gestural control. Its construction was originally motivated by the need for a new instrument on which to perform computer music, and it was designed to replicate as closely as possible the feel of a traditional conducting baton. However, it has unexpectedly become a model for the design of new interfaces and digital objects, and is currently being used to record data for analysis in gesture-recognition research. Some preliminary results and future research areas are discussed at the end.

### Keywords
gestural input, hand-held device, controller, musical instrument, conducting

## INTRODUCTION
The principle motivation for the design of the Digital Baton was to create a gestural controller which replicated as closely as possible the feel of a traditional conducting baton while retaining the maximum number of intuitive control parameters for the user. Therefore, it contains sensing systems which capture many of the modalities of hand motion for input and control of both discrete and continuous functionalities. These systems include an infrared LED tracking system, accelerometers, and pressure sensors, all of which send continuous values for the baton's position, orientation, acceleration, and surface pressure to a computer via an external tracking unit.

The approach taken in building the Digital Baton was to mold, as seamlessly as possible, these systems into the flexible plastic body of the baton. During the design and construction phase of the project, it was realized that the enormous number of separate control parameters available with the Digital Baton and its easy-to-hold design made it an excellent candidate for a more general-purpose gestural interface.

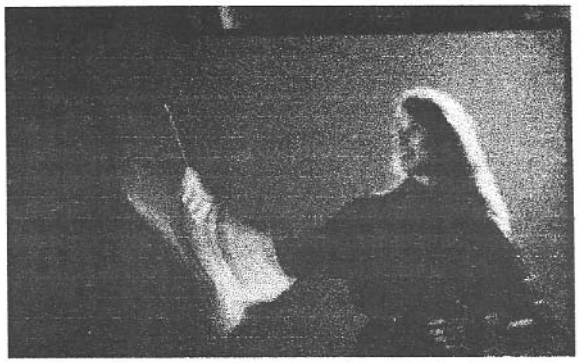

Figure 1. Teresa Marrin conducting with the Digital Baton (photo by Webb Chappell)

## DIGITAL BATON HARDWARE SYSTEM
The Digital Baton hardware system consists of a baton, an external infrared sensor, a tracking unit, and a computer. The sensors on the baton include an infrared LED for positional tracking, five piezo-resistive strips for finger and palm pressure, and three orthogonal accelerometers for beat-tracking. Both the infrared sensor and the baton send separate data streams (including values for absolute 2D position, 3-axis acceleration, 3-axis orientation, and surface pressure) via cable to the tracking unit, which converts and sends the signals to the computer. The body of the instrument consists of a clear tube attached to a urethane base into which the sensors have been molded. Underneath the pliable surface of the base is a hollow, hard shell which houses the more delicate electronics. The whole instrument was designed and molded to be small and easy to hold for any sized hand, with unobtrusive and optimal placement of sensors.

## WHY MAKE NEW MUSICAL INSTRUMENTS?
The motivation for even exploring the issues of embedding sensor systems in musical instruments is that current instruments for the performance of computer music, such as electronic keyboards, breath controllers, and MIDI guitars, are too difficult and unwieldy to use for most situations. On the other hand, standard computer interfaces, such as the mouse and joystick, do not have enough simultaneous

degrees of freedom to phrase a musical line with satisfying complexity. The reason the baton chosen was because it represents a kind of meta-instrument; it makes no sound of its own and has no internal mechanical functionality, and yet, in the conductor's hand, it is used to direct the flow and form of the total musical result. We wanted to combine this notion of the possibility inherent in the baton with the functionalities of a traditional instrument, and ended up with a digital instrument which can execute both the discrete, exactly-timed actions of individual notes and higher-level functions such as shaping volumes and coordinating separate events in time.

## UNEXPECTED RESULTS AND CONCLUSIONS

The Digital Baton project, in addition to revealing a need for new theoretical models and analytical techniques in gesture recognition, taught us a number of important lessons about designing digital electronics into already-existing objects. For one, the set of common suppositions about how an object is to be used do not necessarily hold, once that object is embedded with sensors. Thus, the Digital Baton, while it resembles a traditional baton in many senses, can be used in many more ways than its parent object.

Also, interpreting and responding to gestural events -- particularly expressive gestures for music, whose meaning is not always clearly defined -- requires a completely new theoretical framework. The tradition of musical conducting, an existent gestural language for music, provides a good initial framework, because it is a system of mappings between specific gestural cues and their intended musical results. However, the powerful sensing technologies of the Digital Baton provide the ability to go far beyond the metaphor and functionality of musical conducting, providing the functionalities of a 3D mouse, inertial guidance system, and mini-keyboard in one hand-held device.

The Digital Baton therefore has the potential to provide higher-level control for general-purpose gesture applications in many different fields, and, in addition to continuing in its role as an instrument for real-time performance of computer music, it will also be used in the near future as a data-gathering instrument for gesture-recognition projects in a variety of fields.

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## REFERENCES

1. Arent, Michael, Henry Lieberman, and Laurie Vertelney. "Two Disciplines in Search of an Interface: Reflections on a Design Problem" in The Art of Human-Computer Interface Design, Brenda Laurel, ed., Addison-Wesley, August 1989

2. Darrell, Trevor and Alex. P. Pentland, "Space Time Gestures," Proceedings of the IEEE Conference, CVPR, 1993.

3. Fitzmaurice, G., Ishii, H., Buxton, W., "Bricks: Laying the Foundations for Graspable User Interfaces," Proceedings of Conference on Human Factors in Computing Systems (CHI '95), ACM, Denver, May 1995, pp. 442-449.

4. Ishii, Hiroshi, Minoru Kobayashi, and Kazuho Arita. "Iterative Design of Seamless Collaboration Media." Communications of the ACM, vol. 37, no. 8, August 1994. pp. 83-97.

5. Morita, Hideyuki, Shuji Hashimoto, and Sadamu Ohteru. "A Computer Music System that Follows a Human Conductor." Computer Magazine, vol. 24, no. 7, July 1991, pp. 44-53.

6. Paradiso, Joseph. "Gesture Sensing Technologies in the Brain Opera," to appear in the proceedings of the International Computer Music Conference, September 1997.

7. Sawada, Hideyuki, Shin'ya Ohkura, and Shuji Hashimoto. "Gesture Analysis Using 3D Acceleration Sensor for Music Control." Proceedings of the International Computer Music Conference, 1995. San Francisco: Computer Music Association, 1995, pp. 257-260.