Grouper: A Proof-of-Concept Wearable Wireless Group Coordinator

Fayette W. Shaw
Mechanical Engineering
University of Washington
Seattle, WA 98195-2500
fayshaw@uw.edu

Eric Klavins
Electrical Engineering
University of Washington
Seattle, WA 98195-2500
klavins@uw.edu

ABSTRACT
We introduce *Grouper*, a proof-of-concept wearable wireless group coordinator. Users wear modules each consisting of a microprocessor, a wireless radio, and various electronics to provide sensory cues to users. These sensory cues alert the users to pay attention to the leader of the group, thus augmenting a leader's ability to direct a group. Wearable devices have been used to observe social interactions but few have been used to coordinate a group of users.

Author Keywords
Wearable computing, computational textiles, multi-agent systems.

ACM Classification Keywords
B.7.0 Hardware - Integrated Circuits: General

General Terms
Design.

INTRODUCTION
The goal of this work is to coordinate a group of users through wearable devices. This proof-of-concept system, called *Grouper*, is intended to keep track of a group of users who have a common coordination goal. For example, a teacher may use this system to lead a group of students on a field trip. The Grouper system consists of modules; each module includes a microprocessor, wireless radio, and various other electronics to provide sensory cues to the user. The leader of the group has an additional interface to switch between desired coordination tasks. This system provides sensory cues to both the leader and the other users, thereby augmenting a leader's ability to guide a group. We will henceforth refer to this guided group of users as *followers*.

The Grouper system is envisioned as one that requires minimum attention from the user but will send distinct cues when the follower performs an undesired behavior. For example, a follower's module may display a *safe state* when the follower is performing a behavior correctly, but the follower does not need to continually consult this display. In contrast, when the follower performs an undesired behavior, or is in an *unsafe state*, the module will perform an alert in a clearly perceptible way.

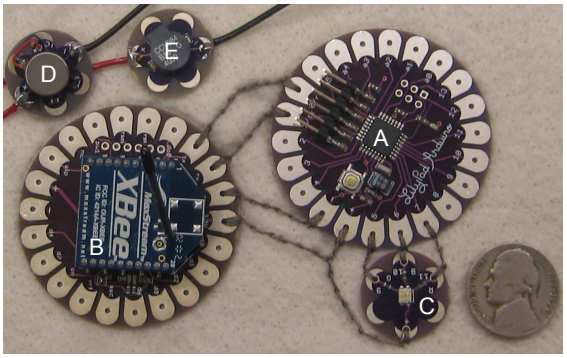

Figure 1. Early prototype of Grouper module. Parts labeled as follows: A) LilyPad Arduino, B) XBee/LilyPad shield, C) Tri-LED, D) vibration motor, E) speaker. Components are connected via conductive thread (except D and E). Nickel for scale.

RELATED WORK
This work is at the intersection of ubiquitous computing, network dynamics, and wireless sensor networks. It is unique in its application of coordinating users using wearable devices. Much work has been done already in multi-agent coordination [3], sensor fusion, and wearable computing [2]. Many works in wearable computing have focused on identifying patterns in social interactions. For example, there are various intelligent badges that track user interactions [4]. There is also work to incorporate biosensors into clothing to aid healthcare and military applications [5]. The main contribution of this work is to not only observe a network structure but to also aid in *coordinating* the group. The second contribution is a proof-of-concept user interface that is conducive for such coordination.

TECHNICAL DESCRIPTION
The advent of the LilyPad Arduino has facilitated the development of wearable devices [1]. The basis of each Grouper module is a LilyPad Arduino and XBee wireless controller. This module has been envisioned so that it is not easily re-

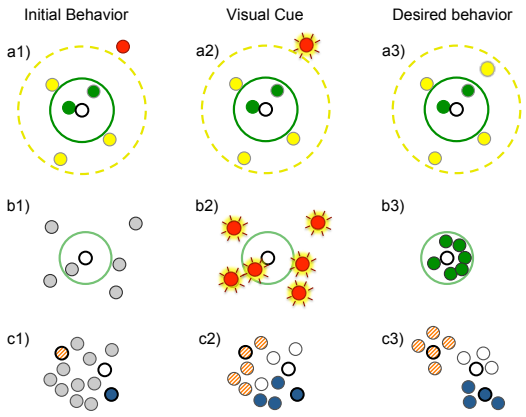

Figure 2. Users demonstrating various behaviors based on sensory cues from their Grouper modules. Each behavior is depicted with three stages: initial behavior (a1,b1,c1), signal from the module(s) (a2,b2,c2), and desired behavior (a3,b3,c3). Leaders are indicated with thick outlines. Figures a1-a3 depict *cluster about the leader*, figures b1-b3 depict *global alert*, and figures c1-c3 depict *divide into groups*.

movable by the follower. Figure 1 depicts an early prototype of this device.

DEMO SUMMARY

We demonstrate three behaviors: cluster about the leader, global alert, and divide into groups. Each is depicted in figure 2 with an undesired behavior, visual cue, and resulting desired behavior. The first, *cluster about the leader*, requires each node to be within a threshold distance from the leader, as indicated by concentric circles. This distance is approximately proportional to received signal strength from the leader. A follower in each region will display different colored LEDs to indicate its safety state: green (close) and yellow (less close) represent safe states, while red is an unsafe state. Additionally, a follower in the red unsafe will hear a speaker alarm and feel and vibrating motor. In figure 2, an agent has entered an unsafe state (a1), receives a sensory cue (flashing LED, vibrating motor, and speaker siren) (a2), and returns to a safe state (yellow) (a3).

The second behavior, *global alert*, is used when the leader wants the attention of all the followers and thus sends an alert cue to all followers, regardless of distance. Followers are represented in gray (light shading) to indicate the initial behavior(b1). A leader sends global signal to all users, a cue that is similar the red unsafe state in the cluster about the leader behavior except that is is broadcast to all followers (b2). The followers then cluster around the leader (b3).

The third behavior, *divide into groups*, is shown with three leaders with white, orange (hashed), and blue (dark solid) LEDs for identification and unassigned followers are gray (light solid) (c1). Followers are assigned a group based on proximity (c2). Group colors are chosen to be disjoint from the colors of the safety states so that follower modules can express both safety and assignment states. Using this combined visual cues, followers cluster about their sub-group leader (c3).

APPLICATIONS

This application was conceived in the context of organizing school groups, where students are often outfitted with brightly colored vests and shirts. Adding such a device to a garment is minimally intrusive and increases the likelihood that the module is associated with the person. This system may be particularly applicable to groups that already wear uniforms and perform tactical team coordination, such as in military operations, firefighting, or team sports.

CONCLUSION

This work is in its early stages of development and no preliminary results are available. The Grouper system serves to demonstrate a proof-of-concept system that provides sensory cues to draw attention to both users and followers. Future work includes designing the form factor of the Grouper modules to be wearable but minimally intrusive, and embedded in a badge, bracelet, or shirt. Current design decisions are not optimal; the protoype may be significantly improved by replacing the present LEDs with super-bright LEDs or electroluminscent (EL) wire to improve visual observation. A leader could then identify a follower's state from a greater distance and these cues would be much more obvious for the follower as well. Much work will be done to design a user interface so that the users are conducive to these sensory cues. Lastly, the capabilities of the Grouper system would be considerably more vast with the inclusion of sensors to incorporate geometry.

ACKNOWLEDGEMENTS

We thank Shwetak Patel and Eric Larson for invaluable feedback and Tam Minor for her work on hardware. This work is supported in part by NSF grant #0735953 EFRI-ARESCI.

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