Blind Navigation on the Water Through Shared Assistive Technology

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ABSTRACT

Paddle sports can be an easy to learn and enjoyable way for people to improve health, fitness, and socialization outcomes. However, for the blind and low vision community to safely navigate on the open water, most visually impaired paddlers require paddling in a multi-person boat with a sighted guide or bellowing directional commands. Although these solutions enable visually impaired paddlers to enjoy the water, they limit the freedom, peace, and independence that sighted paddlers normally experience from being alone in a boat. In our research, we are working with an organization that provides socialization, fitness, and competitive sporting opportunities to the visually impaired community through outrigger canoeing. In coordination with our ongoing fieldwork, we are collaboratively developing a shared-control assistive technology called CoOP (Cooperative Outrigger Paddling). The CoOP system removes many of the limitations that blind and low-vision paddlers face while paddling, serving as a first step to the complex world of navigating on the water without vision.

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Figure 1: A blind paddler competing in a race with CoOP, a shared assistive technology for cooperative outrigger paddling. This was the first blind novice paddler participating in an OC1 race. Using CoOP, the paddler is responsible for all aspects of boat control except for steering. A sighted partner follows nearby to transmit directional changes to the canoe rudder.

KEYWORDS

Accessibility; assistive technology; blind navigation; visual impairment

INTRODUCTION

As a physical activity, outrigger canoeing has been well suited for individuals who are blind or low-vision when operating a multi-person boat configuration with a sighted guide. The organization that we work alongside, The Makapo Aquatics Project (http://makapo.org), organizes weekly paddling events that provide individuals with visual impairments access to one (OC1), two (OC2), and six (OC6) person outrigger canoes. In OC2 and OC6, a sighted paddler is responsible for directional control, whereas the OC1 requires a sighted guide in a secondary boat to provide audible navigational cues. One of the ways that Makapo brings attention to its work is through competition. Makapo has placed mixed blind and sighted crews in OC6 races across the United States. To be competitive, however, paddlers must develop skill and fitness levels, which can only be achieved through practice in the OC1. However, according to Makapo, the efforts required to provide adequate navigation directions prevents their coaches from providing adequate paddling instruction.

Developing assistive technologies for aquatic activity presents unique perspectives and challenges that contribute to the ways in which we might think about designing for blind navigation. In this paper, we present some guidelines for the design of CoOP, and briefly discuss their implications for designing for blind navigation in general.

THE COOP SYSTEM

CoOP is a shared-control assistive technology that supports remote steering to enable blind and low vision OC1 paddlers to focus on improving their skill and fitness (see Figure 1). In its current configuration, CoOP requires a paddler, navigator, and support boat guide. The paddler's primary role is to make adjustments in balance and paddle stroke. The support boat guide sets the route on the water, maintaining a safe distance from obstacles and other boats. The navigator remains on the support boat and uses the CoOP transmitter to steer the paddler. CoOP is comprised of a 3D printed harness, high-torque servo motor, lithium polymer battery, and entry level commodity remote control transmitter and receiver.

Our design approach draws on guidelines and insights from assistive technology design literature within HCI. In analyzing outrigger canoeing practices, we adhered to the principles of ability-based design [5], derived inspiration from the perspectives of engagement described by Shinohara and Wobbrock [4], paired opportunities and challenges for exercise technologies identified by Rector et al. [3], and utilized a do-it-yourself (DIY) approach to working around many of the obstacles that visually impaired consumers face when purchasing assistive devices [2].

Figure 2: Various iterations of the CoOP-prototypes in order of improvement from top to bottom. The third iteration (bottom image) represents the combined insights from our findings and input from the paddling community.

The development of CoOP took place over the course of thirteen sessions from January to October 2018, each lasting two to three hours. Each session involved an iterative evaluation of our prototype and post-evaluation interviews and discussion. An OC1 is controlled by a paddle and foot pedal operated rudder system connected by a tiller cap (see Figure 2). The tiller cap, binds the pedal cables to the rudder, providing 180 degrees of turn from port (paddler's left) to starboard (paddler's right). CoOP utilizes a custom tiller cap, a semi-permanent replacement made from 3D printed ABS plastic. The remaining components of the system are designed to be attached and removed at each use by a blind individual—by providing tactile placement and alignment cues. The natural progression of the project ranged from planning, to real world operation, to enabling the participation of the first novice blind paddler in a local OC1 race (See Figure 1). Through preliminary interviews with Makapo, and the development process, we established several criteria to consider as we were building an assistive technology for blind and low vision paddlers in the OC1. Here is a small sample that have insights relevant to blind navigation in general:

(1) *Attentive navigation solutions distract from the experience of the activity.* Auditory navigation instructions were either difficult to translate into actions or they distracted visually impaired paddlers, which prevented them from achieving desired level of fitness for OC6 competition. We especially wanted to respect the auditory channel in our design to not compete with the overall enjoyment and experience of solo paddling on the water.
(2) *Avoid permanent modifications.* Resource sharing can be a strategy for communities to enable greater access to activities, as Makapo does by providing boats to paddlers with a wide range of visual acuity. As a way to respect these shared resources, our modifications needed to be easily be attached and removed from a boat.
(3) *Avoid changes to default operation.* Occasionally, a paddler was in a situation where they wanted the feeling of fully controlling OC1 or needed to make a panic stop. Not changing the default operation of OC1 instead of having it be purely remote controlled allowed paddlers to have more autonomy when desired or required.
(4) *Allow control by novices, not just trained coaches.* Paddling an OC1 depends on the availability of a coach, or at the very least, someone who has prior experience with audible navigation. We designed the control interface to be more natural to avoid limiting the excursion and training opportunities for blind and low vision paddlers. Furthermore, with the ease of more natural control, coaches can focus on paddling instruction rather than navigation.

CONTRIBUTION TO THE WORKSHOP

A common challenge when designing for individuals with disabilities is gaining access to the community for running user studies. Our partners were cautious to allow their community to become subjects of an experiment that would give undue hope or stress without having something that they could use in the foreseeable future. In light of this, we took a community focused, collaborative design approach. The current iteration of our prototype is intentionally designed around shared control between a visually impaired paddler and a sighted guide. In previous work, we have extensively explored the physicality of assistive technology design [1], finding that an orientation towards shared control with computation can reshape our understanding of how such systems should operate. By starting lower-fidelity, with a remote controlled version, we were able to quickly iterate to a working prototype that not only meets the immediate needs of one paddling community, but also raises interesting insights and questions around autonomy and independence in blind navigation. Furthermore, now that we have a working relationship with mutual respect, we have the opportunity to collaborate on a more autonomous version in the future.

We could have taken more of a waterfall design approach, but developing CoOP at the Newport Aquatic Center continues to generate outcomes we would not have gained working exclusively in the lab. In particular, our current prototype incorporates design elements inspired by solicited and unsolicited feedback from members of the broader paddling community, Makapo paddlers have developed deeper connections to the technology, and an increased awareness of the capabilities of blind paddlers has been brought to the sighted paddling community.

Although our findings are contextualized to the experiences of a small group of visually impaired outrigger canoe paddlers, we are interested in exploring paths towards generalization beyond the water. How can public development be used to shape the built environment in ways that reduce the complexity of navigational assistive technologies? What experiences emerge from shared assistive technologies that change how researchers tackle challenges in blind navigation? We hope to explore these questions and more in greater depth through workshop collaboration.

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