Experiencing VOS: a Visual Orientation System

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Abstract
This demo introduces *VOS – a Visual Orientation System*. Since orientation without visual cues is challenging for humans, situations in which visibility is limited pose hindrance and sometimes a threat to human activities. To explore the augmentation design space that enables focusing the sense of hearing, we chose a particular application scenario: swimming in open-water. We developed augmented swimming-goggles that provide visual feedback to complement the sense of orientation. Currently, we explore different information encoding methods. The presented prototype illustrates the differences between using a continuous signal to convey absolute directions and discrete signals to indicate a relative direction.

Author Keywords
Swimming; augmented senses; HCI for sports; Sense enhancement.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
The sense of direction and orientation involves the vestibular sense, the senses of hearing and sight, and a mental mapping of the environment. [8, 5]

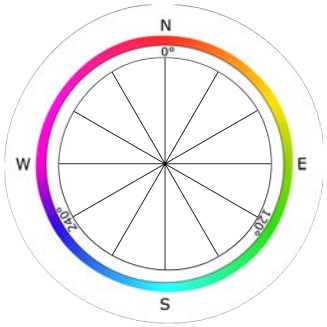

Figure 1: Colour mapping: the visible colour spectrum is mapped to the four cardinal directions, matching pure red with the North, pure green with 120° respect the North and pure blue with 240°.

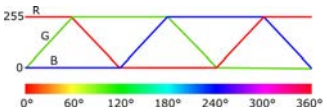

Figure 2: Using the RGB colour coding, each angular direction is mapped to a linear combination of red, green and blue, resulting in the tones displayed in the bottom bar.

A deprivation of visual and auditory cues hinders the mapping process, resulting in a poor sense of direction. This effect makes navigation challenging and, in some cases, poses a threat to health and safety. Such is the case that might be experienced by swimmers in open-waters, hikers in the fog or in the dark, divers or fire-fighters.

To explore the problem, we address swimming in open-waters as a study case, since it is the easiest and safest application scenario to investigate. In open waters, swimmers have insufficient visual references to keep a consistent direction. This results in the impossibility of swimming in a straight line and forces swimmers to stop periodically to look for visual cues above the surface, or consult a compass or GPS device, which causes exhaustion and sub-optimal routes [6].

Based on literature about head-mounted navigation feedback [7] [9] and presenting information to swimmers through wearables [2, 3, 1], we designed a Visual Orientation System (VOS), a system capable of providing directional cues to users by means of subtle light signals [4].

Concept and Implementation

The goal of our design is to enhance the sense of direction. Such a system requires a way of detecting directions and a method to present this information to users.

The simplest method to measure directions is with a compass. Thus, we used a three-axis magnetometer to detect headings respect the Earth's natural dipole. We designed the device to be wearable and the majority of swimmers use goggles, we have to consider and compensate for the head movements of the user. To achieve this, we used a three-axis accelerometer and a gyroscope, which allow tracking the devices angular position respect the Earth's surface.

For our prototype, we use a board from Adafruit[1], that provides all three sensors embedded in a single integrated circuit. We control this device with an Arduino Mini Pro, which polls the sensors and performs the needed calculations.

The orientation cues are provided to the user using two RGB LEDs. The Arduino board controls both LEDs, providing light stimuli to the user. The LEDs are attached to the outer side of the goggles and positioned in the outer field of view of each eye to avoid obtruding sight but to still be noticeable constantly.

The device is powered with a coin-cell battery and enclosed in a vacuum-sealed plastic bag, to make it waterproof. Once enclosed, the electronic controllers can be affixed to the goggles with rubber bands (see Figure 3) . The flexible bag allows actuating the device's controls without additional difficulty.

Figure 3: VOS prototype. The electronics are enclosed in a waterproof bag and attached to the swimming goggles with elastic bands.

In the current design stage we are evaluating two different signal modes, which have advantages over each other according to the goals of the user:

[1] https://www.adafruit.com/product/1714

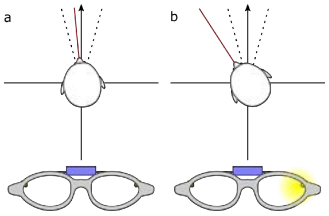

Figure 4: Discrete feedback: (a) the system allows the user a predefined deviation threshold, (b) when the user deviates beyond the threshold, a signal shows towards with direction to turn back.

Absolute continuous orientation
The system indicates absolute directions using colours. We map the colour of RGB LEDs to the angular deviation respect North in degrees (see Figure 1), starting with pure red for North, pure green at 120° (roughly SSE) and pure blue for 240° (roughly SSW). The intermediate colour values are mapped linearly between the two pure colours delimiting the interval for each value.

Each direction is thus associated to a unique colour, with a granularity limited only by the colour spectrum that the 24bit RGB standard can provide (see Figure 2) and the resolution of the sensors.

This signal mode favours a sense of general direction when no specific direction is preferred, but a general orientation.

Relative discrete orientation
The system indicates deviations from a chosen direction. This is beneficial when the goal of the user is to maintain a heading: the system provides feedback to the user only when correction is needed, indicating towards which direction the users needs to correct their heading.

The cues consist of a single LED shining on the side towards which the user should turn to, when the user deviates beyond a predefined threshold (see Figure 4). To ensure visibility in most underwater scenarios, the LED shines in yellow.

This signal mode does not provide information about the absolute or general orientation, but helps the user maintain a particular direction with a high degree of precision.

Demo setup

Two physical prototypes will be available for demonstrations. Participants will receive an introductory explanation, after which they can wear the goggles and walk around the venue. A series of targets (paper prints taped to walls) will be positioned in the demonstration space, so that participants can navigate the room using only the feedback provided by the device. Participants will be encouraged to try to reach that point looking at their own feet and since closing their eyes will be strongly discouraged to avoid accidents.

Conclusion

We present a working prototype of a visual navigation aid for swimmers. With this contribution we plan to make tangible to users and researchers the design proposed in VOS – Designing a Visual Orientation System [4]. By offering people the possibility of experiencing our system, we hope to both prompt discussions that help us reflect on this proof-of-concept, and inspire further research in the topic.

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