Using Vibrotactile Communication to Assist in Orientation and Locomotion

Victor Adriel de Jesus Oliveira and Anderson Maciel
Instituto de Informática (INF)
Universidade Federal do Rio Grande do Sul (UFRGS)
Porto Alegre, Brasil
Email: {vajoliveira,amaciel}@inf.ufrgs.br

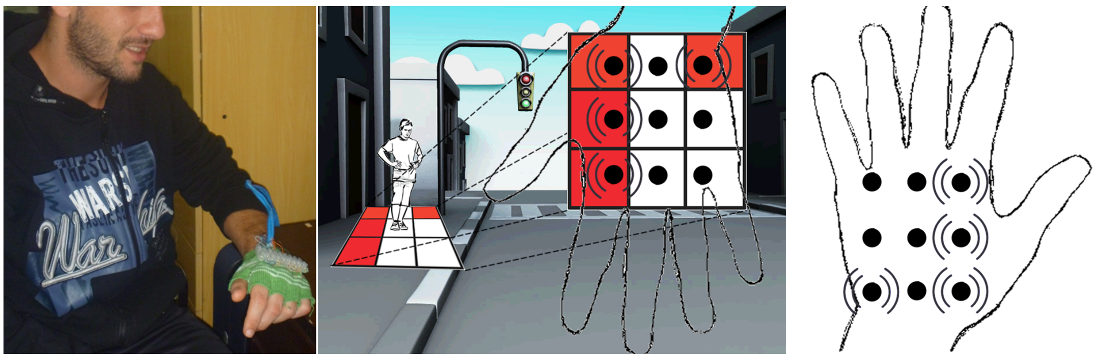

Fig. 1. A glove with a 3x3 tactors grid used to map the elements of the space around the user.

***Abstract*—This paper introduces a research which aims to demonstrate that the use of a haptic language, consisting of signs with a higher level of expressiveness, can effectively help a user in their locomotion, complementing or even replacing their vision. We propose to develop a network of haptic actuators using a set of patterns to express elements of an environment with obstacles and free paths. This is used to assist the orientation and locomotion of a user either in virtual or real worlds. Preliminary results and future work are presented and discussed.**

***Keywords*-vibrotactile communication; tactile display; haptics;**

I. Introduction

The research and development of haptic technologies can be divided roughly into two broad areas: the creation of hardware and software to simulate several tactile sensations; and the study and development of vibrotactile communication. The research proposed in this paper focuses on the second large area, which the main purpose has been to discover a set of tactile patterns that can be discriminated, rapidly processed, and easily learned [1].

This project started from the need to develop an application that would help the locomotion of the blind. In this context, devices exist that collect information from the environment through sonar and translate this information into aural format. To use a vibrotactile language for communication with the user seems be the best alternative when you want to avoid overloading the hearing of those users. Thus, the tactile display can be used not only for blind or deaf, taking the place of their vision or hearing, but also for any user as an additional communication channel. The tactile display could be used by the military to assist their walking in the dark or by firefighters in rescue situations where there is a lot of smoke and noise, for example.

Other tactile displays have been developed to assist motion and orientation using an iconical mapping where the position of the tactor corresponds to the direction of an object or the direction which the user should move in. This approach is known as tap-on-shoulders, and is equivalent to a stimulus that directs the user to perform a certain action.

Expected contributions: The main difference between most of the existing projects and the proposed approach is to use a haptic language composed of both the iconic and arbitrary signs for the purpose of giving greater expressive power of the tactile display.

II. Related work

Wearable tactile displays promote mobility and proximity of the actuators with the user's skin. For the construction of displays such as these, micromotors may be attached in belts, clothes, watches or scattered at strategic points of the body transmitting warning information [2] or assisting in postural correction [3], in learning dance moves, mobility or orientation in space.

To facilitate navigation in the real environment there are suits equipped with arrays of micro-motors which drive the user issuing haptic navigational signals. Some studies use a system of tracking and route planning using haptics to signal when the user should stop or move in one direction [4] while others detect the location of obstacles and, from that information, suggest a safe path to the user [5] .

There are also studies that do not suggest a path. Instead, they only signal the position or direction of obstacles present around the user. One approach maps the user's field of view onto a grid of actuators that vibrate in the position corresponding to the detected obstacles in front of the user [6]. Some other designs use belts to encircle the trunk of the user with actuators that vibrate in the trunk positions corresponding to positions of obstacles around targets [7], [8].

III. DEVELOPMENT

The focus of this work will be exploiting the potential of vibrotactile communication. Therefore, the tactile device should be built to display as much information as desired in order to assist the user during their locomotion. The tactile display created will render relevant information such as the existence of obstacles on the path, characteristics of the route and alert information.

Initially, this tool will be used in virtual environments to validate initial research hypotheses related to the limits of tactile acuity in the human somatosensory system. Moreover, it will be used to assess the haptic construction of expressive languages which have reasonable learning curves within that scope. Some initial hypotheses were drawn from the observation of characteristics present in some languages, such as sign language and their signs. Other hypotheses are yet to be raised from the deeper study of haptic communication and linguistics. After validation of these hypotheses, the current prototype tool should be adapted to allow its use also in the real world.

IV. PRELIMINARY TESTS

A prototype has been built to validate the hypothesis that it is possible to create a simple but expressive language which can effectively help the user in moving an avatar in a virtual environment. This prototype consists of a glove containing a grid of tactors.

In the human body, the hands have high sensitivity and tactile acuity. This justifies the creation of a tactile display to be placed on the user's hands. Nine tactors $ROB - 08449$, each with $3.4mm$, were arranged in a 3x3 grid on a glove to be used for navigation in a virtual environment full of obstacles and low lighting for preliminary tests. The grid is used to map the elements of space around the user, as shown in Fig. 1. In this mapping, eight actuators represent iconically the obstacles around the user, while the center (second row and second column) corresponds to the position of the user. This latter could be used to reproduce a signal modifier, which changes the meaning of a signal when they are joined. In other words, each actuator represents a region of the delimited space around the user and vibrates if exists an obstacle there. Therefore, each pattern consists of a set of active actuators which is equals to the number of obstacles present around the user in a particular position.

Some activation sequences have been experienced using an Arduino Mega board. We observed that more distinguishable signals are generated from the vibration of micromotors which are farther away from each other in the grid (Fig. 2). Later on, we plan to build a mesh with more actuators to further explore the possibilities of vibrotactile communication.

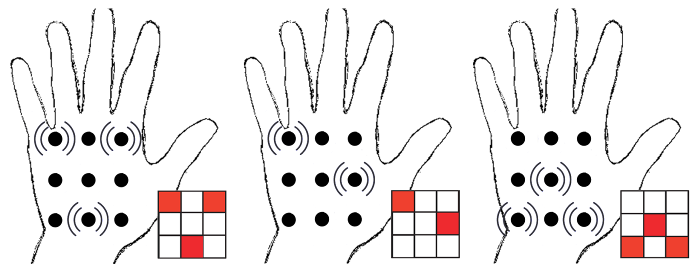

Fig. 2. More distinguishable vibrotactile signals.

V. DISCUSSION AND FUTURE STEPS

Most of the tools built for auxiliary user locomotion and orientation, both in the virtual and real worlds, use tactile displays for produce iconic patterns to symbolize routes or obstacles. The research proposed in this paper will explore several possibilities for vibrotactile communication to create a more expressive haptic language contributing to the decisions of the user during their locomotion.

In the continuation of this project we intend to establish communication between the Arduino board and the Unity3D game engine. Tests will be performed to collect the count of mistakes made in a walk through a path in a virtual space. Light intensity and amount of obstacles will vary to detect helpfulness of the system in different conditions. Other tests will also be performed to analyze the distances between actuators that best avoid misinterpretation and also to test the use of two gloves simultaneously.

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