Windfield: Demonstrating Wind Meteorology with Handheld Haptic Robots

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ABSTRACT

One of the main issues with the acceptance of robotic tools in schools is the extracurricular aspect of the learning activities using these robots. In the Cellulo project, we developed a novel robotic platform that aims to provide a *ubiquitous*, *versatile* and *practical* tool for teachers with subjects varying among the different topics at their respective school curricula. In order to show the potential of Cellulo in the classroom as part of standard curricular activities, we designed a learning activity called *Windfield* that aims to teach the atmospheric formation mechanism of wind to early middle school children.

Keywords

Human-Robot Interaction; Robots for Learning; Haptic Interfaces; Tangible Robots

1. INTRODUCTION

After the tentative of introducing robotic tools in schools during the 70's and 80's, efforts dropped and robots disappeared from schools for about two decades. Apart from the fact that robots were expensive and unreliable, Gander *et. al.* argued in [1] that one of the reasons for this failure was what he called the *teacher availability deadlock* : "As long as computer sciences is not in the curriculum, there is little incentive to educate teachers in the subject; as long as there are no teachers, there is little incentive to introduce the subject.". Indeed, for a robotic tool to be used in school environments, they need to have their usefulness and ease of use proved in the teacher's practice. The Cellulo project (described in detail in [6]) addresses this challenge of showing teachers that robotic tools can be used in schools in various curricular activities.

In this practical demonstration, we propose an instance of these curricular activities that deals with meteorology and gradient of atmospheric pressure leading to wind forces. Participants will be able to feel the wind & the gradient of pressure holding the robot in their hand and using it as a haptic device.

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Figure 1: Windfield experiment being carried out by a group of 2 students. Low and high atmospheric pressure points are hidden on the map, creating winds and pushing the Cellulo robots that represent hot air balloons. Learners probe the map with their robots to feel the wind and discover the hidden pressure points.

The following section describes the technical overview of the activity Cellulo framework within *Windfield*. We then conclude on future works and experiment that will be conducted with similar setups.

2. TECHNICAL OVERVIEW

Our system relies on the interaction of the following three components:

- *the robots*: used for displaying visual and haptic information,
- *the paper*: used for the spatial localization of the robots and displaying graphical information, and

- *the tablet*: used to orchestrate the activity.

In this section we will detail each of these three components and their interactions.

2.1 Robot

The robots were designed to fit in the hand and to be as identity-less as possible. Their localization relies on the decoding of a visual microdot pattern printed on the paper (see [2]). The decoding is done entirely onboard, allowing each robot to get its full 3DOF pose (x, y, θ) on the paper with high accuracy. Each robot is connected via Bluetooth to the tablet to which their pose is sent.

The robots are equipped with a permanent-magnet assisted ball drive for locomotion (see [3]) allowing omnidirectional motion and providing a robustness mechanism against mechanical damage due to external manipulation. This new design also allows us to render planar haptic feedback through a hybrid motion-haptics controller [4].

Finally, the robots also possess LEDs used for visual display and tactile sensors to assist the motion-haptics controller by detecting whether the robot is grasped.

2.2 Paper

The paper allows the robots to localize themselves and displays graphical information for the users. These graphical information can be used as referential by the students to discuss ideas and strategies (”Try to feel the wind near Athens”). We can also use this paper playground to define zones that can trigger some robots' behavior. For instance, when the robot passes through a city, we could display information about the climate in that particular city on the tablet.

2.3 Tablet application

The tablet application runs the logic of the activity. The tablet is connected to the robots via Bluetooth and includes a representation of the physical map on which the robots are. Latency-critical or high-bandwidth software components are built within the robots' firmware (e.g. motion controller, localization) while components that require high computational/memory resources or need to change depending on the activity are offloaded to the per- activity QtQuick applications that run on the tablet.

In the *Windfield* activity, robots act as hot air balloons. When grasped, they render the intensity and direction of the wind at this particular position on a map of Europe. Using this haptic information, users are invited to guess where pressure points, generating the wind, are located.

3. CONCLUSION

The Windfield activity demonstrate practicality and educational potential of our system. This activity was tested in a course setup with 24 children split in groups of 3 (see [5] for findings regarding this experiment) On the technical aspect, this activity showed the deployability of a light robotic kit composed of only robots, a paper poster and a tablet. We showed various modes of interaction with the students aiming to favor multimodality and collaboration.

In the future, we would like to explore the versatile potential of the platform in educational contexts. We are currently developing new activities touching other areas of the curricula. These new activities are being developed in collaboration with educational practitioners and will be tested in a real classroom environment. We also plan to evaluate the learning potential of the haptic display.

4. ACKNOWLEDGMENTS

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