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Abstract of Thesis

Name (Anna Carolina Soares Medeiros)	
Title	Design, Evaluation and Deployment of Gestural Interfaces: From Multicultural Perception to Accessible Multi-Scale Interactions (ジェスチャインタフェースの設計、評価、および展開：多文化的な認識から理解しやすいマルチスケールインタラクションまで)

Abstract of Thesis

Gestural Interface uses body movements to give commands to a computational system; it can complement or substitute navigation in a conventional interface. The present work explores Gestural Interfaces from the conceptual development process of choosing gestures to a system function until the application and implementation of gestures in short and long distances settings; here referred to as ``multi-scaled" interaction. A short-scaled gesture interface was analyzed by users in Brazil and Japan, whereas the multi-scaled gesture interface was developed and studied in Japan.

The Gesture Development Process presented here provides a flexible solution for system functions with varying levels of complexity and enables collaboration and reuse of past efforts. To illustrate the Gesture Development Process, gestures for the standard system functions “Select,” “Rotate,” “Translate,” “Scale,” and “Stop” were developed.

Analyzing how gesture interfaces are perceived in different parts of the world can help in the reuse of gestural interfaces created for a specific culture and help understand possible weak and strong points, allowing for improvements to the interfaces. This study also aims to analyze how different technological familiarization levels impact gestural interfaces' user experience. This work describes the findings of an experiment replicated in two countries: Brazil and Japan. In each experiment, 20 subjects tested two applications; one had a mouse-based interface, one had a gesture-based interface. User experience was measured using questionnaires.
The gestural interface was perceived similarly in both countries. This similarity is a cue for reusing the gestures developed for one user-group with the other.

Multi-scaled interaction scenarios include short-scaled interaction where user, camera, and interaction targets are all close together (within 3 meters), and long-scaled interaction scenarios, where the distances between the user, camera, and targets provide far more challenges. For example, when pointing to targets far away, the slightest change in the pointing line will significantly increase the final destination.

This thesis investigates multi-scaled interaction scenarios. The author used a drone to provide accessibility outdoors, where the Firefighting scenario needed a long distance between user-drone and user-target. For this purpose, the author conducted a Preliminary Interview and User Study with seven subjects from the Kobe Firefighting Brigade, Japan. As a drone's flight and locomotion properties significantly affect the user's mental and physical expectations differently than other grounded robots, a careful investigation of user-defined design preferences and interactions is required. This work proposes an examination and discussion, with experienced firefighters, about Human-Drone Interactions when relying solely on the drone's monocular

camera, without relying on other devices such as GPS or external cameras. The User Study had three main elements: A drone, a building, and the volunteering firefighters. During the study, each firefighter should specify a window to the drone. The drone would theoretically use that window to enter the building and perform some designed task, like information gathering, thus saving the firefighter time and effort. Results show that the subjects always chose Pointing Gestures and voice commands to communicate to the drone a target window.

The author first built a 2D gesture interface application with the resulting gesture from this investigation. Since that 2D interface failed to show satisfactory results, a 3D gesture interface application was proposed. The author includes a description of the process for detecting and localizing objects and carrying out the transformations between coordinate systems. The proposed 3D pointing gesture interface improves the previous 2D pointing gesture interface by integrating depth information with Simultaneous Localization and Mapping (SLAM) Techniques, solving multiple objects aligned on the same plane ambiguity in a large-scale outdoor environment. Experimental results showed that the 3D pointing gesture interface obtained a 0.85 and 0.73 F1-Score on average in simulation and real-world experiments and 0.58 F1-Score at the maximum distance of 25 meters between drone and building.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

This thesis presents the design, evaluation, and development of multi-cultural and multi-scale Gestural Interface. The present work explores Gestural Interfaces from the multi-cultural gesture development process of choosing gestures to a given system function, until the application and implementation of gestures in short and long distances settings; here referred to as "multi-scaled" interaction. The contributions of the thesis are summarized in the following two parts.

The first contribution is an analysis of how gesture interfaces are perceived in different parts of the world, namely the multi-cultural gesture development process. The result of the study will help to reuse gestural interfaces created for a specific culture in other cultural contexts. It will also help understanding possible weak and strong points of the interface, allowing for improvements of the interfaces. This study also aims to analyze how different technological familiarization levels impact the user experience of gestural interfaces. This work describes the findings of empirical studies conducted in two countries: Brazil and Japan. In each experiment, 20 subjects tested two interfaces; a mouse-based interface and a gesture-based interface. User experience was measured using questionnaires. As a result, the gestural interface was perceived similarly in both countries, which provides a cue for reusing the gestures developed for one user group with the other.

The second contribution is the development of multi-scaled interaction scenarios. These include a short-scaled interaction where user, camera, and interaction targets are all close together (within 3 meters) and a long-scaled one where the distances between the user, camera, and target are more than 3 meters. The thesis includes an empirical study of the multi-scaled gesture interaction scenarios. The author used a drone to provide outdoor accessibility, where a distance between user-drone and user-target is relatively large in the chosen Firefighting context. For this purpose, the author conducted a preliminary interview and user study with seven subjects from the Kobe Firefighting Brigade, Japan. As a drone's flight and locomotion properties significantly affect the user's mental and physical expectations compared to other grounded robots, a careful investigation of user-defined design preferences and interactions is required. This work is composed of an examination and discussion, with experienced firefighters, about Human-Drone Interactions when relying solely on the drone's monocular camera, without relying on other devices such as GPS or external cameras. The user study had three main elements: a drone, a building, and the volunteering firefighters. During the investigation, each firefighter should specify a window to the drone. The drone would theoretically use that window to enter the building and perform some designed tasks such as information gathering, saving the firefighter time and effort. The results show that the subjects always chose Pointing Gestures and voice commands to communicate a location of the target window to the crone. The author compared a 2D gesture interface and a 3D gesture interface and found the 3D interface produced a better result. In this thesis, developed is a description of detecting and localizing objects and carrying out the transformations between coordinate systems. The proposed 3D pointing gesture interface improves the 2D pointing gesture interface by integrating depth information with simultaneous localization and mapping (SLAM) techniques, solving multiple objects aligned on the same plane with ambiguity in a large-scale outdoor environment. Experimental results showed that the 3D pointing gesture interface obtained a 0.85 and 0.73 F1-Score on average in simulation and real-world experiments and 0.58 F1-Score at the maximum distance of 25 meters between drone and building.

These contributions have been published in major journals or international conferences in the relevant research area. In conclusion, this dissertation has a significant contribution to advance the user interface/human-robot interaction study and worth to be awarded the Ph. D in Information Science.