AugmEnted ROBotIc Control

- AEROBIC, MINDEF -

Project Report

Neuromorphic Engineering & Robotics/SiNAPSE

National University of Singapore
Center for Life Science

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AugmEnted ROBotIc Control

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Todo list

Preface

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National University of Singapore, November 25, 2016

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Chapter 1

Objectives

Fast Motion Segmentation with Neuromorphic Sensors Utilizing Biological Principles A biologically inspired algorithm utilizing saccade like micro-motions to capture data from a neuromorphic imager was developed. The algorithm concerns the development of novel asynchronous signal processing algorithms to process information resulting from the micro-motions.

Vibro-Tactile Haptic Glove We aim at designing a lightweight, wireless vibro-tactile glove to facilitate human perception of remote robotic environments. The vibratory actuators are placed at sensitive locations of the palm to deliver precise and localized haptic feedback. The objective is to make these gloves robust to user's hand poses.

Virtual Reality Visualization The project enables a VR environment (CAVE or virtual headset) to communicate, transfer and render data wirelessly at a low latency between robots and haptic gloves. In case of haptic gloves, the objective is to allow rendition of virtual objects in form of vibratory stimuli. In case of robots, the objective is to transfer visual scene information in near real-time from remotely located robots to a VR environment. In addition, a tele-operator can control the robots to perform appropriate actions as tracking and following other objects and object recognition.

Chapter 2

Materials and Methods

Motion Segmentation

As reported in D9, we developed a novel motion segmentation algorithm utilizing neuromorphic vision sensor. The algorithm was characterized by experiments in controlled environments. The paper has been submitted to Frontiers in Neuroscience. The next step was to integrate the algorithm with a virtual reality platform, allowing a controller to remotely visualize the environment and interact with the robot.
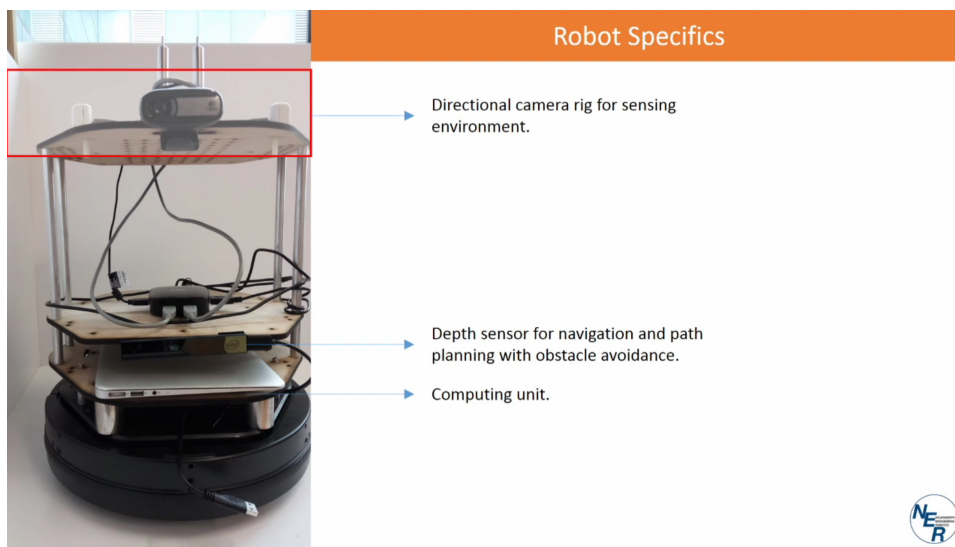

Figure 1. Sensor integration in the robotic platform for experiments.. The robot is ROS-enabled and allows development of algorithms within the ROS ecosystem.

In this report, we emphasize on the development of (1) the robotic platform

for integrating various sensors for navigation and motion segmentation and (2) wireless data transfer and rendition in a virtual reality platform. As shown in Figure 2.1, we use the turtlebot robotic platform to integrate the sensors and algorithms. The robot comprises three USB cameras with their field of views (FoV) aligned such that they form a continuous scene when rendered consecutively. The robot is equipped with a RGBD sensor, Intel's RealSense R200, allowing the robot to make a map of its environment and perform path planning. A central computing unit is responsible for executing the algorithms for path planning, obstacle avoidance, motion segmentation and wireless environment image transfer.

Figure 2.2 shows the corresponding data as received by the virtual reality platform. The current implementation uses image data encoded as a motion-JPEG (mjpg) video stream at $20fps$, rendered by a viewer such as a web browser. The robot is located in a remote location and implements the algorithms for navigation, path planning and obstacle avoidance.

Figure 2. Rendition of data from the robot.   Data from the three directional cameras installed on the robot is displayed in the virtual reality platform.

Figure 2.3(A) shows the 2D map that is calculated and stored locally on the robot's computing unit for navigation and obstacle avoidance. The arrow indicates the location of the robot in the map with the corresponding physical location as shown in Figure 2.3(B). A gesture tracking algorithm was developed that manipulates robot's motion parameters in real-time.

Figure 3. Robot's map and physical location. (A) A 2D map created using the RGBD sensor is shown. (B) The corresponding physical location of the robot is shown.

Vibro-Tactile Haptic Glove

The second generation of vibro-tactile haptic gloves was developed. These gloves have the capability of rendering spatial touch information with amplitude modulation. The high-density gloves have 18 vibratory eccentric rotating mass actuators. The actuator locations were selected to deliver haptic feedback at the most used and sensitive areas on the palm-side of the hand during exploratory procedures. The actuators are held in place by a flexible PCB, made from polyimide, to closely represent the topography of the hand, minimize wiring complexities, prevent displacements after prolonged usage and give a more natural skin-like feel. The control box is placed at the wrist location. The vibration intensity and their activation is controlled wirelessly through a graphical user interface (GUI) that is designed to send custom stimulation patterns. The GUI enables single and multiple actuator activation with amplitude modulation for intensity control. In near-field operation the latency is low permitting real-time feedback. The control box consists of two pulse width modulation (PWM) drivers and one Arduino microcontroller. The computer transmitting an encoded stimulation signal received by the control box initiates the communication pathway. This signal is sent to a microcontroller for actuation. In addition, the control box contains a power source for the system. A prototype of the second generation haptic glove is show in Figure 1.

As reported in D9 report, we developed the second generation vibro-tactile gloves with flexible PCB to reduce wiring. However due to the stiffness of the PCB and the dissipation of vibro-tactile stimuli on the palm region experienced by the user, we developed third generation of vibrotactile glove. In this version, we use wires to fasten the actuators and give the user a more natural feel.

In the third-generation, eighteen actuators are placed at sensitive locations of

human's hand. This generation of haptic glove is flexible and light weight.

VR Simulation

We aim at rendering complex virtual objects as shown in Figure 2, to the user by mapping their shapes to the vibratory stimuli on the haptic glove.

A VR environment is built inside the CAVE with 4 projectors using Unity development platform. We have developed a pick and place VR simulation as shown in Figure 3. We are evaluating strategies for the rendition of 3-dimensional geometric shapes to the user with the vibro-tactile glove.

An ART D-track system as shown in Figure 4, is used to track the position and the movement of a user accurately in the VR environment. The ART-DTracking(Advanced Realtime Tracking) system, which is used for interaction in this case, will be used for providing gesture data. Simple clustering algorithms are used to locate the human hand and body. The position data is then translated and recorded into position data in the VR system for further usage.

This tracking system will also be used by a tele-operator to interact with a virtual avatar of the robot deployed in a remote location. Depth sensors like RealSense or Kinect are used to render the scene around robot in the VR environment.

Chapter 3

Results

Motion Segmentation

We were able to achieve data transmission from the robot with very less latency. We also demonstrated the use of gestures in the virtual reality platform to alter the robot's navigation parameters. A sample video showing this can be found at <give vimeo link here>. Using Mozilla as the platform for visualization of data allows implementation of MozVR based APIs in the system. The VR system was able to understand gestures (left swipe, right swipe, and pinch) using the installed infra-red optical trackers.
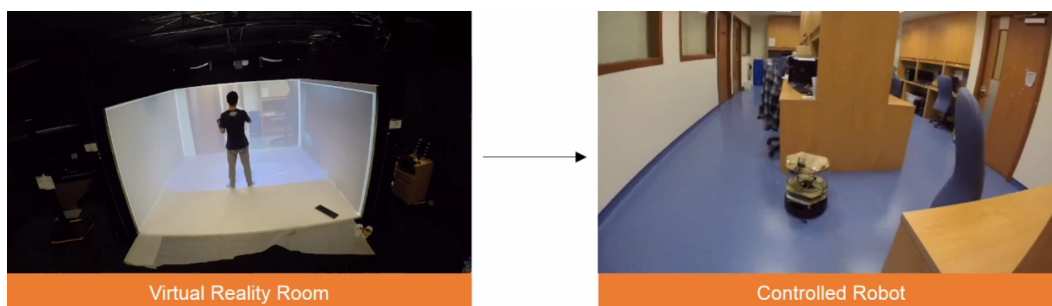

Figure 1. Real-time robot control and data visualization.

Vibro-Tactile Haptic Glove

Chapter 4

Future Plans

Motion Segmentation

Future work will involve the following:

- Development of an API for processing a gesture language. Gestures will be used to direct the robot to identify objects of particular category and follow them using the motion segmentation algorithm with a neuromorphic vision sensor.

- Develop a method to render point-cloud information from the scene in the VR room. This will be possible by transferring data encoded in *XDM* format.

- An algorithm to enable tracking-following will be developed by utilizing the previous work on motion segmentation. This algorithm will develop a computation layer on top of the motion segmentation algorithm to localize on specific objects in the environment. A study will be performed to compare and quantify the results obtained, and the paper submitted to Frontiers in Neuromorphic Engineering.

Appendix A

Appendix A name

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