Hardware implementation of several ideas for Multimodal Human-Robot Dialogue and Stereoscopic Telepresence

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SMMI & Stereoscopic Tele-presence
(application examples)
SMMI – Secured Multimodal Interaction (WP1 of A*Star Industrial Robotics Programme (2013-2016))

Motivation:

- Traditional use of keyboard, mouse and touchscreen monitor should be excluded on the future industrial shop floor.
- Robotic glove also needs alternative.

- Instead, a Dialogue should be implemented between the human and the robot by using Multiple Modalities for:
  - Programming by Demonstration (PBD)
  - Augmented Reality (AR)

- Such dialogue may include:
  - problem statement, making offers, discussion,
  - compromise, approval,
  - execution, supervision.

Project Participants:

PI: Seet Gim Lee Gerald (Assoc Professor)
RF: Iastrebov Viatcheslav (Dr)
Mr. Dinh Quang Huy (Ph.D Student)
RF: Mrs. Pang Wee Ching
Proposed Features for the Dialogue System

Limitations for industry:

• Speech modality in industrial area is often difficult, thus people used to communicate via the gestures of their hands and fingers, light and laser pointers, writing words on available common desks.
• Second hand is often required for safety purposes.

We suggested:

• Create a natural hand-extension device, which should be held in one hand and detect haptic and motions inputs.
• Use See-through Head Mounted Glasses-Display (HMD)
• Implement Laser Graphics on the surrounding surfaces
Framework for Human & Robot Partner Interactions

(Created by Prof. Gerald Seet)
A hardware complex of a **multimodal single-handed handheld device** for PBD, **see-through head mounted glasses-display for AR** and a **color laser projector** mounted on the robot and capable of drawing bright and contrast AR-spatial graphics on the common for human and robot surfaces.

See-through Head Mounted Display (HMD with camera & IMU)

Laser outlining projector (LOP) with camera

Epson Moverio BT200

Handheld Haptic & Gesture Interface (HGIF)
Brainstorm before prototyping of single-handed input device

Existing single-handed haptic & gesture input devices

- CyberGlove III
- Reactive Grip
- Ring Mouse
- Trackball Mouse
- Intuitive Vibrotactile Feedback
- Right-handed XBOX 360 Controller

Sketches of novel haptic device
Haptic and Gesture User Interface (HGIF) Controller

- **ARDUINO PRO MINI 3.3V**
- **WIFI Transceiver**
- **Li-Po Battery 11.1V & charging balancer**
- **50mW Green Laser Pointer**
- **Slide Potentiometer**
- **OLED Display**
- **LIDAR - Near Infrared 40m Rangefinder**
- **5 Spring-return linear displacement Sensors 12-38mm**
- **A/D ARDUINO PRO MINI 3.3V**
- **Blue Tooth**
- **IMU 10 DOF**
- **Voltage Regulator**
Brainstorm about Single-handed Clamping the Wrist (+Videos)

Predator-2 Spear gun

5th Element Zorg ZF-1
HGIF (Haptic & Gesture Interface)
Components & Peculiarities

Peculiarities of the device:

• Any number of fingers can do the work from fast pushing button to soft proportional control;
• No need to search for a button to push as each finger is sensing own button;
• Each finger feels that the work is being done due to a spring-return sensation.
• Can work as fidget anti-stress tool:
• Hand gestures provide redundancy in control variations.
• Can trigger emergency by reflex pressing all buttons and shaking the hand
HGIF Electrical diagram
(Components from eBay, AliExpress, Sparkfun, Adafruit, SG Robotics, BEI Sensors…)

Diagram showing various components and their connections, including:
- I2C 0.96 OLED Display Blue-Yellow
- Arduino Pro Mini
- Bluetooth Modem - Blue SMIIF Gold
- Lidar-Lite near Infrared Rangefinder
- 50mW Green Laser Pointer
- WiFi Transceiver Wireless Module
- 10 DOF L3G20 L3MD20D BMP280 Gyro Accelerometer Compass Altimeter
- Battery 12V with Charging Board
- 5 Force-returning Haptic Pedal Inputs

Various hand gestures and inputs like thumbs, index fingers, middle fingers, ring fingers, and small fingers are also shown.

Diagram includes detailed wiring and components layout.
Laser Graphic Projector for Spatial Augmented reality in Human-Robot Dialogue
Using Projectors instead of Displays
Tilt Mechanism for Laser Writer & Video Projector
MAVEN Holonomic platforms – Electrical Diagram
Estimated industrial applications of SMMI

Crane hook follows a laser-pointed trajectory

Robot inscribes over the projected line on a ship hull
SMMI Snapshots & Video
SMMI Results

• Framework
• Developed Hardware
• Developed Software
• Conducted Tests
Underwater Robotic Vehicle (URV) for monitoring of underwater pipes (2001-2008)

Sponsor & Customer - British Gas Asia Pacific Pte Ltd
Stereoscopic Tele-presence Viewing System for “Perceptual Constancy” enhancement

Examining the details of the 3D object captured by the remote stereoscopic camera, brought to an idea of hardware implementation of the principle, described in this publication: “Andrew Woods, Tom Docherty, Rolf Koch, “Image distortions in stereoscopic video systems stereoscopic displays and applications IV”, Proceedings of the SPIE Volume 1915, San Jose, CA, Feb. 1993”.

The relationship between object distance away from the camera system and image distance away from the eyes (viewing distance) is almost linear within the range of 1 meter, as shown in Fig → Beyond that it is highly non-linear.

1. Continuous measurement of the object distance and automatic live regulation of the camera zoom to maintain the object image within 1m from the eyes + Sitting within 1m distance away from the monitor (if any).

2. Manual remote adjustment of converging angles of the cameras to move the 3D image of object to a comfortable position for each user, may show details previously unavailable.

Idea is as follows:
To increase the eye comfort, the image viewing distance should be made equal to the object distance. This is achieved through an active zoom control of the camera. If the focal length of the camera and the viewing distance are equal and don’t exceed 1 meter, there will be an added comfort to the eye and this may give a more realistic image.

The focus is on shape and size constancy to help human sensing Perceptual Constancy.
Manual and automatic adjustment of an Object Position against the monitor screen

Relation between the cameras convergence and the object position against the monitor screen:

a) Behind the object ↔ in front of the screen;
b) On the object ↔ on the screen;
c) In front of the object ↔ behind the screen.

Water tank experimental installation
Results & Conclusion

- We have demonstrated a hardware implementation of Perceptual Constancy, which is to provide constancy of an object’s size as well as the dimensional ratio between the object and the background.
- This implementation has reduced the visual strain for all the experiment participants.
- Our research has also shown visual perceptiveness of objects in 3D degradation in a turbid environment.
- The degradation effects of the stereoscopic display were quantified and correlated with different levels of turbidity in the detection of camouflaged target and the distance estimation experiment.

- Figure presents the mean hit percentages of all subjects for each viewing condition and for four levels of water turbidity.
- It is possible to observe, from Figure, that the hit percentages when stereoscopic vision is available are significantly higher than that when monoscopic vision is provided.


Many Thanks
For your kind
Attention!
Robotic Vehicle with Side Scanning Sonar for Shallow Water Reservoirs

New Carrier for the Side-Scanning Sonar has a round shape of the frame and 3 reverse motor-driven propellers. Dynamical positioning is provided basing on the complex navigation via GPS, Magnetic Compass, Gyroscope, Accelerometer, Speedometers.

Side-scanned image of the mannequin, dressed in T-shirt and pants. Due to the relatively high carrying frequency of the transducers (340 and 675 KHz), the naked mannequin was acoustically invisible for this type of acoustic waves.
RF Sensor for Real Time Detection of Negative Obstacles from the Unmanned Ground Vehicle

**Objective**
Detect negative obstacles on the paved road from the moving UGV and investigate how to distinguish between the negative and the positive obstacles at a distance of over 8-12 meters in real time.

**Method**
A Radar system generates a pencil-beam of continuous-wave (CW) type. It is installed on a UGV, facing forward with a downward slant of the main lobe(s) of the radar beam(s).

An example of detection of the hole composed by removal of the grid cover at NTU campus: