

Game-Based Design of Human-Robot Interfaces

Notes on USSR design papers
(2004-2006)

Presented by Misha Kostandov



Papers



- B. Keyes, R. Casey, H. A. Yanco, B. A. Maxwell, and Y. Georgiev
"Camera Placement and Multi-Camera Fusion for Remote Robot Operation"
IEEE Int'l Workshop on Safety, Security and Rescue Robotics, 2006
- B. A. Maxwell, N. Ward, and F. Heckel
"Game-Based Design of Human-Robot Interfaces for Urban Search and Rescue"
CHI 2004 Fringe, 2004
- B. A. Maxwell, N. Ward, and F. Heckel
"A Configurable Interface and Architecture for Robot Rescue"
AAAI Mobile Robotics Workshop, 2004
- B. A. Maxwell, N. Ward, and F. Heckel
"A Human-Robot Interface for Urban Search and Rescue"
AAAI Mobile Robot Competition and Exhibition Workshop, 2003



Background

- Urban Search and Rescue event (since 2000)
 - AAI Robot Competition
- Human in the loop
 - limited navigational autonomy
 - effective UI is important





HRI Awareness

- Human Robot Awareness [Drury et al. 2003]

Human's understanding of the location, activities, status, and surroundings of the robot, *and*

Knowledge that the robot has of the human's commands necessary to direct its activities and the constraints

UI should provide sufficient info to make decisions at required level of decision-making



HRI Awareness

- Surroundings awareness
 - Local environment
 - Video lag time and bandwidth are crucial
 - Long lag -> instability in control loop

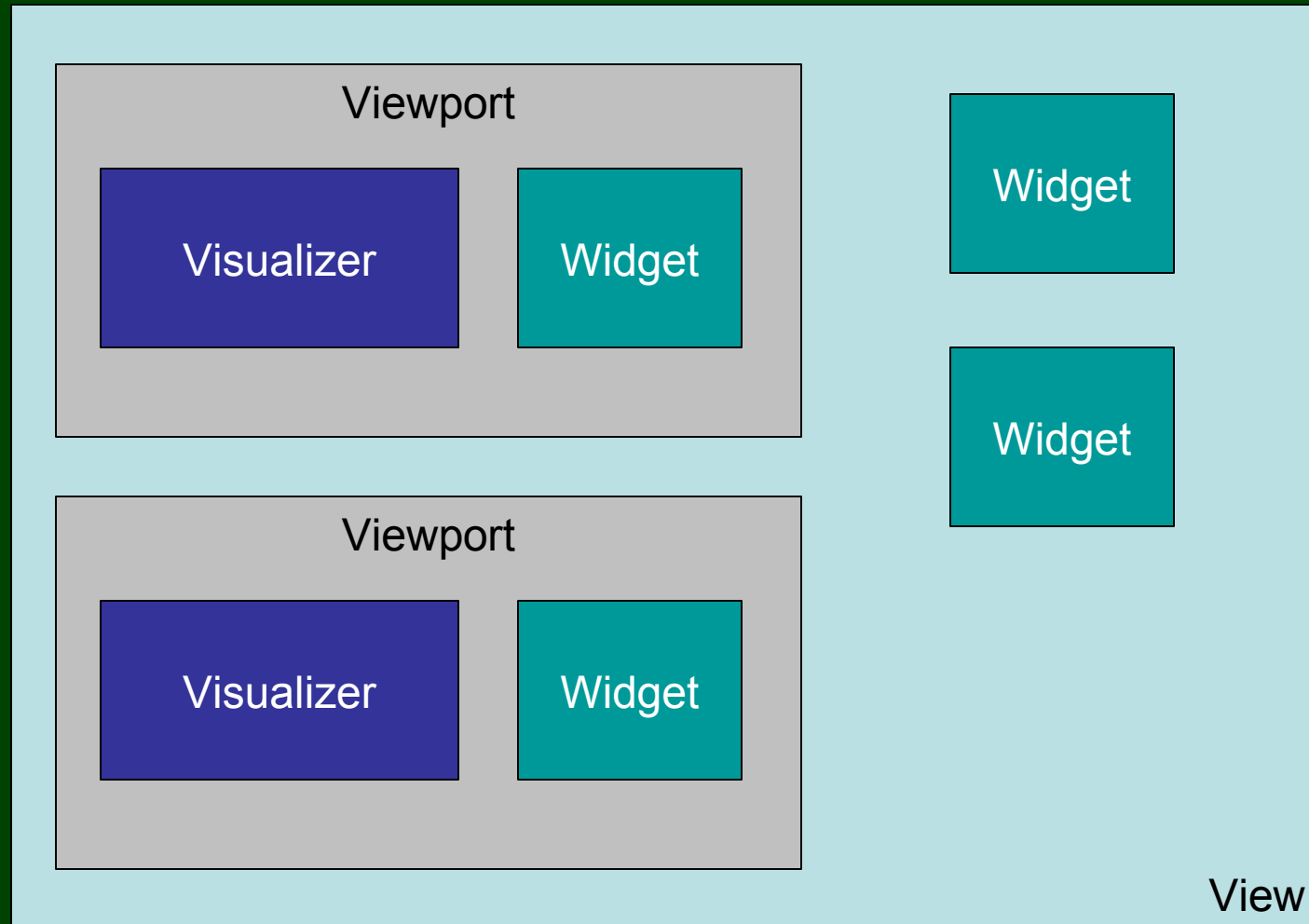
- Status awareness
 - State of the robot



FPS motivation

- FPS games are the most appropriate paradigm
 - Represent a 3D world with which the player interacts
- Task analogy
 - Searching for CG enemies in FPS
 - Searching for injured victims in USR
- Main focus
 - Intelligible
 - Informative
 - Useful

Interface Design



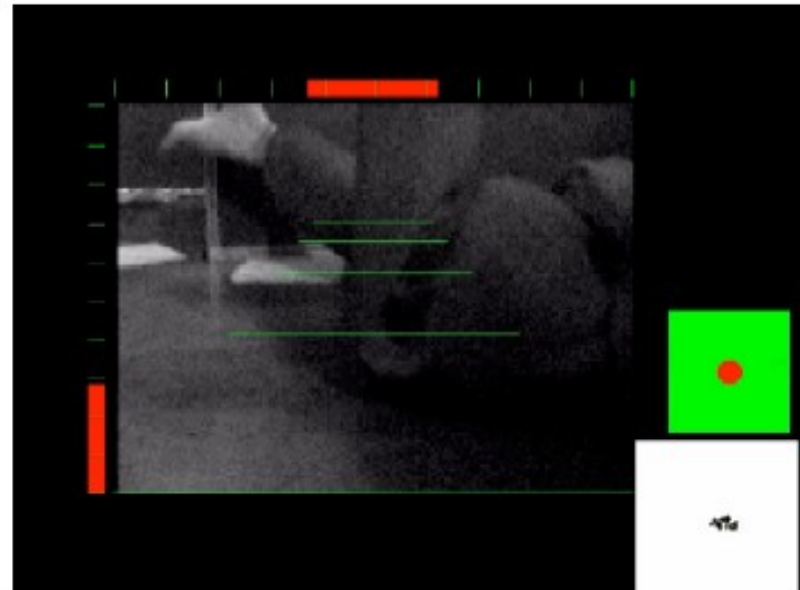
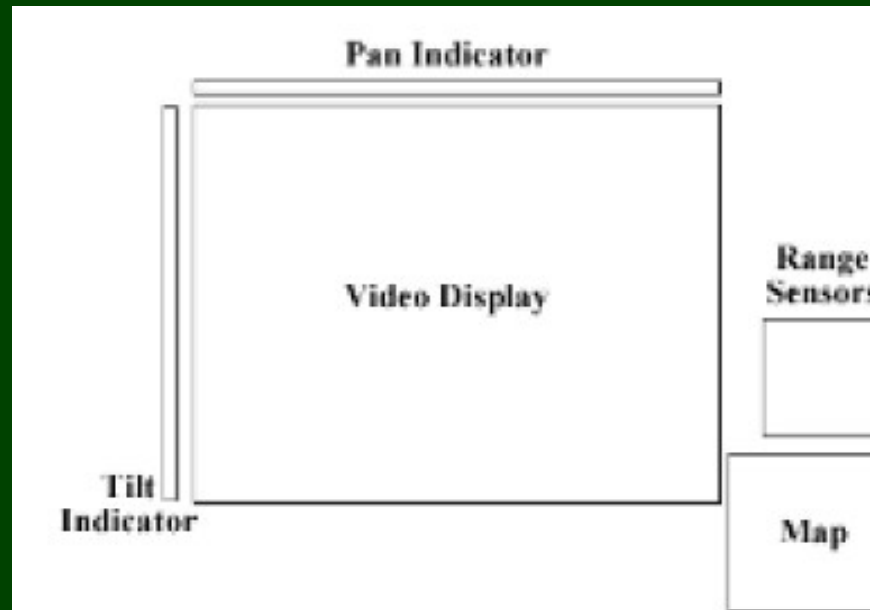


Configuration

- XML config file
 - Connection info
 - Metadata
 - Modules
 - Controllers
 - Layout of viewports
 - Message and control bindings for visualizers and widgets
- Human readable

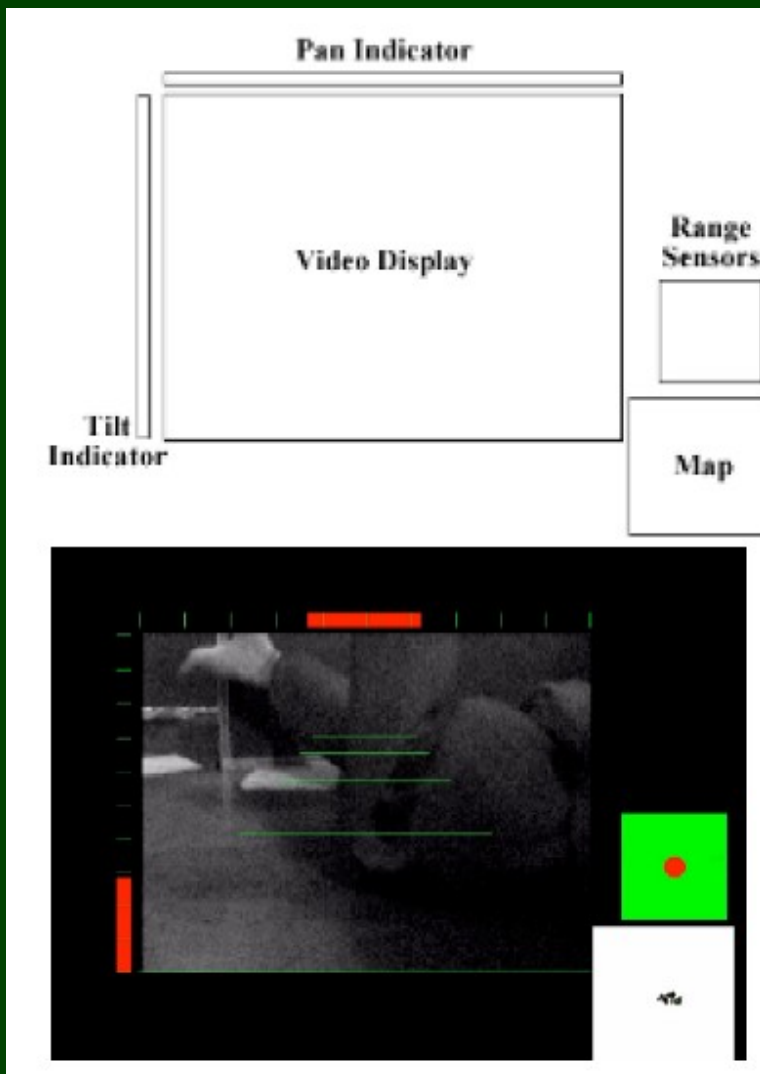


Example configuration

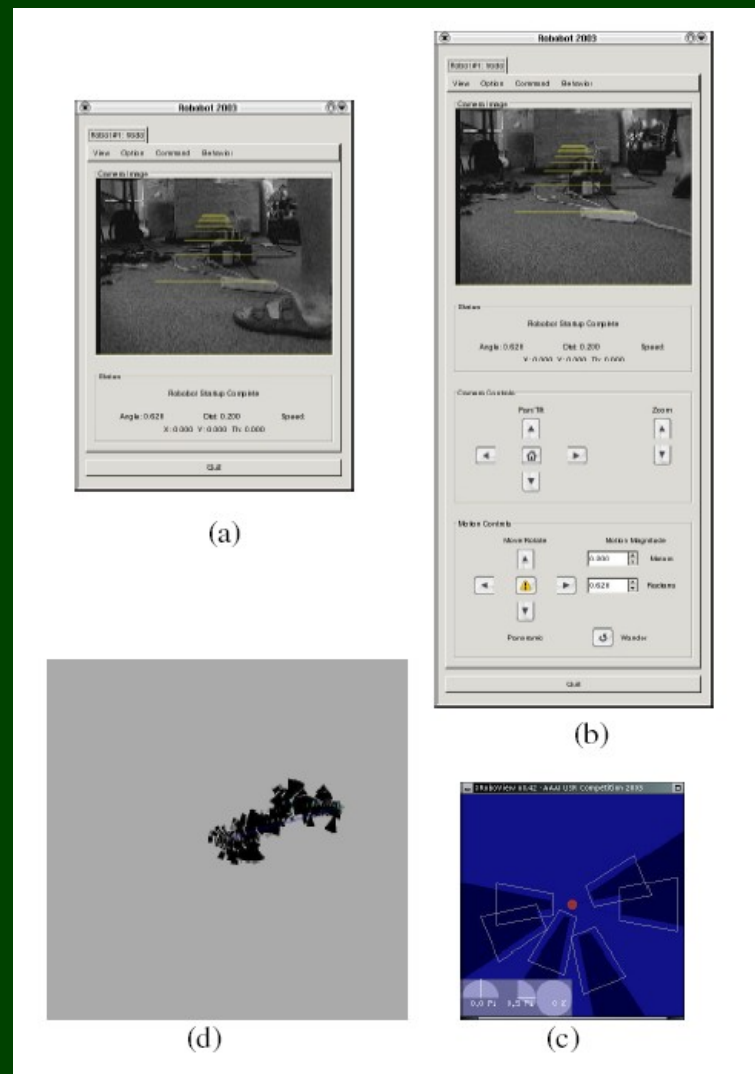




Interface Comparison



2004, joystick



2003, mouse



Robot Control

- Interface A:
 - Mouselook not available
 - All robot/camera control by keyboard
 - Robot mvmt:

W
A S D

, camera mvmt:

U
H J K
 - Hands always on keyboard, using fast-twitch muscles
- Interface B:
 - Most controls on the joystick



Interest Points

- Setting and manipulation of interest points with mouse
 - Uses robot position and camera orientation to determine the point location in the world
 - Assumes clicks are on the ground plane
 - Can create associated metadata (victim info)
- Can adjust previously set landmarks to correct localization



Interface discussion

- Keyboard interface easy for an experienced user / new user with FPS gaming experience
 - More efficient and easy to adjust to
- Problematic for new operators
- In USR task: increased efficiency is more important than usability for a wide range of inexperienced users



Operator disorientation

- Large rotations exacerbated the motion errors, disoriented the operator
 - Largely due to video blur and lag
- Nudging with short forward and angular motion worked better
 - Maps are more accurate as well!
- Camera orientation / range info important for operator perception of orientation



Camera Placement/Fusion [Keyes et al. 2006]

- Situation awareness is a critical factor in teleoperation
- Better views assist in more effective navigation
- Study:
 - Overhead view camera
 - Two-camera setup (front and rear)

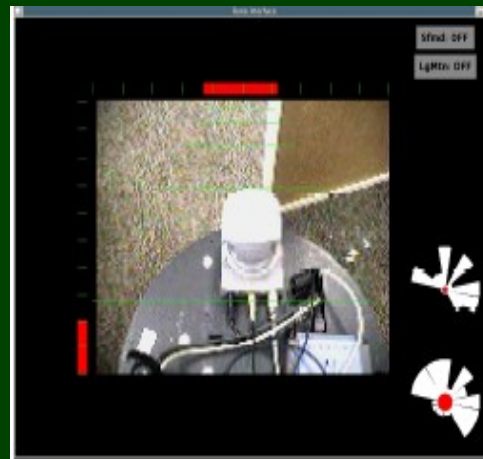
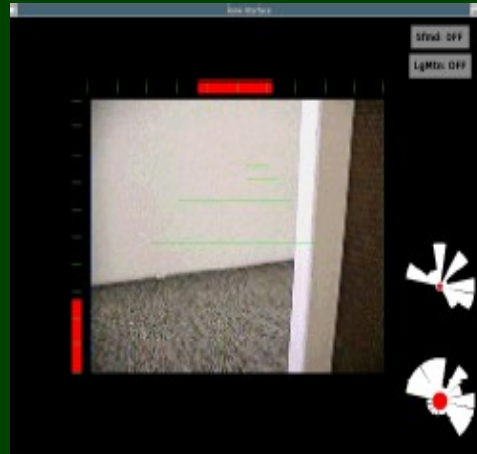
Compared to single forward-looking camera

Overhead and Forward Cameras

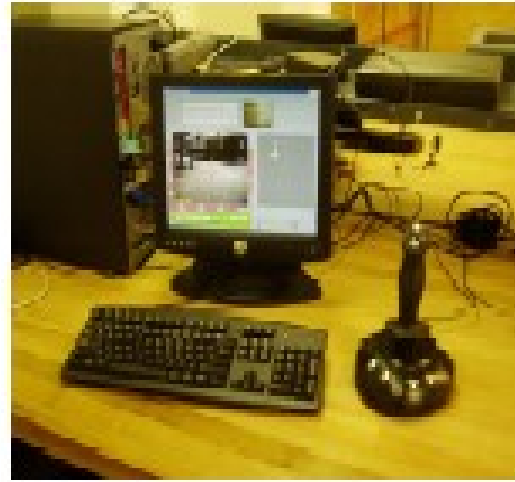


iRobot Magellan Pro

Overhead and Forward Cameras

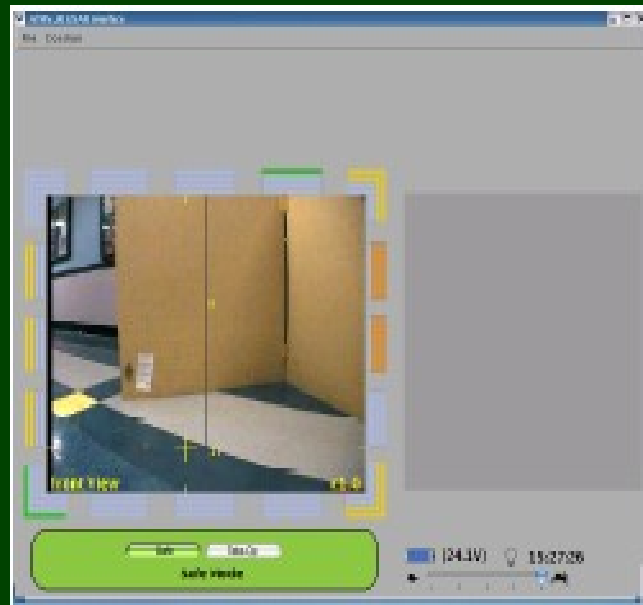


Front and Rear Cameras



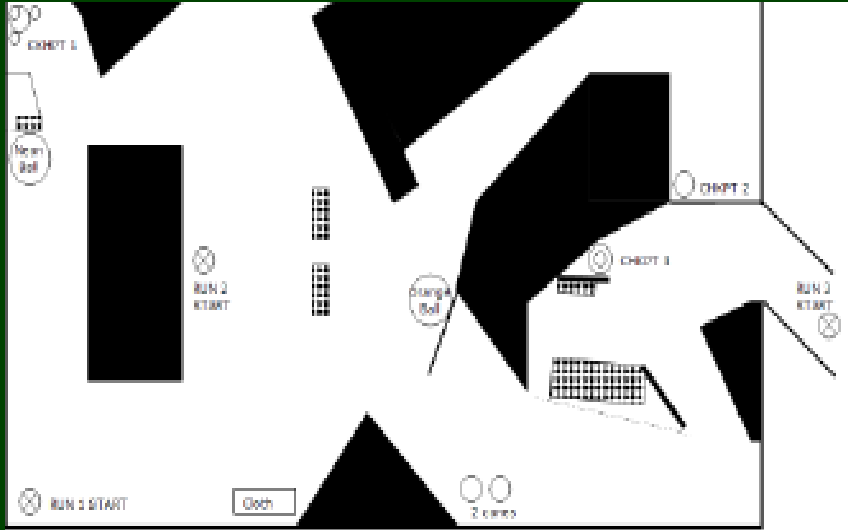
iRobot ATRV-JR

Front and Rear Cameras





User Study Environment





User Study

- Overhead vs forward cameras

Setups:

- Forward
- Overhead
- Switchable view

- One vs two cameras

Setups:

- Forward
- Switchable view
- Two windows

- Task: finding objects
- Tracking: time on task, number of collisions



Results

- `/* here be statistics */`
- Overhead view and two-camera setup decreases collisions
- If you only have one camera, give user a view of a portion of the robot
- If you have two cameras, use the second one for rear view rather than alternative forward view





