Human Interaction with Robots
Working in Complex and Hazardous Environments

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Human Interaction with Robots Working in Complex and Hazardous Environments

- Preliminaries
  - Complex and Hazardous?
  - Robots?
  - Human Interaction?
  - Needs for Performance Improvements?
- Modern Telerobot?
  - System Concept & Architecture
  - Where should research foci be?
- Current Research…Telerobotics
  - Experimental System
  - Results
  - Future Directions
- Closing Remarks
Complex and Hazardous?

- Remote operations in hazardous and **uncertain** environments…**unstructured**
  - Nuclear, Space, Underwater, Medical Surgery…
- Remote work systems that involve:
  - Remote sensing
  - Manipulators
  - Mobility
  - **Use of tools**
- Human-in-the-loop operations/control
Robot?... Telerobotics

- Telerobots?
  - Telerobot = Teleoperator U Robot
  - tR = Robot U Teleoperator
  - Tr = Teleoperator U Robot
  - tR ≠ Tr
  - Manual control U Autonomous operations

- Human interaction
- Computer assisted teleoperation
- Selective autonomy
Human Interaction…

- **Teleaction**
  - Tasks
  - Tools

- **Telepresence**
  - Sensors
  - Manipulators
  - Mobile Transporter

- **Physical/Temporal/Hazards Barriers**
  - Human/Machine Interface
  - Signals
  - Power

- **Human/Machine Interface**
Decades of Refinements...
Needs...

- **Reality:**
  - Too expensive
  - Too slow
  - Too complicated

- **Improve remote work efficiency**
  - Best: direct/teleaction $\geq 10$
  - Worst: direct/teleaction $\sim 100$’s

- **Open engineering**
  - Power supply and transmission; cable handling
  - 3D remote viewing and sensing
Telerobot Functional Architecture

- HMI Autonomous Operations
- HMI Teleoperations
- Interactive Task Planner
- In Situ Model Builder
- Cooperative Assists Planner
- Control
- Fault Detection & Recovery
- Mobility
- Task Space
- Sensors
- Manipulation
- Tooling

RTSA
TR Control

Computer assisted teleops

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Critical Performance Issues

HUMAN-MACHINE COOPERATIVE TELEROBOTIC PROCESS

Select and configure assistance strategy

Execute manually with assistance

Manual teleoperation

Remote Operations Task Sequence

Seamless Transfer Essential

Subtask \(i\)

\(i+1\)

\(i+2\)

\(i+3\)

\(i+4\)

Build in situ 3D model

Plan subtask

Execute automatically

Verify results

Manual teleoperation

ROBOT TASK SCENE ANALYZER PROCESS

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Telerobot Control Structure

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Research Test Bed

Dual remote manipulators...
Human Interactive Task Space Modeling and Planning

Max use of a priori knowledge
Parallel Execution
Operator Control
Where, what, and how.
Acceptance of results.
Simplified GUI
5 pop-up window menus
Color overlays
± 10 mm in robot workspace
REMOTE OPERATIONS TASK SEQUENCE

SUBTASK_1: Manual
SUBTASK_2: Auto
SUBTASK_3: Auto
TELEROBOTIC SUBTASK SEQUENCE
SUBTASK_1:
RTSA BUILD IN SITU 3D Model
PLAN SUB-TASK
EXE-CUTE
VERIFY RESULTS

8-10 min 4 min 18 min

32 min versus 45-90 min Teleop

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Recent activities…

- 7 dof “haptic” controller
  - Barrett Technologies WAM
- Large-scale multi-fingered end effector
  - Barrett Technologies Wraptor
- Reduced tool specializations
- Controller integration
  - Tooling: behavior-based grasping
- Test & evaluation
Continuing Research

Continuing Research

Abort Plan Sequence
Original Plan Sequence
Re-Plan Sequence

Fault state/step
"Drift" state/step
Fault state/step

Retrace/restart original
Start re-plan

Fault Detection & Recovery
Interactive Task Planner
In Situ Model Builder
Cooperative Assists Planner
Control
Fault Detection & Recovery

Operational Space Fault Detection

HMI Autonomous Operations
HMI Teleoperations

Computer assisted teleops

Manipulation
Tooling
Task Space

RTSA
TR Control

Tool-based Control

Intelligent/interactive State Management

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Higher-fidelity telepresence and teleaction... needs, directions...

- Perception/Sensing
  - 3D viewing
  - 3D graphics augmentation
  - Natural kinesthetic/tactile feedback

- Intelligence/Control
  - Human relationships
    - Interactivity reduced through increasing autonomy
    - More cooperative
    - Humans move up in hierarchy
  - Machine learning
    - By observation – symbiosis

- Action/Manipulation
  - Multi-fingered end effectors

- Human Machine Interface
  - Algorithmic complexity
  - VR-based interfaces
Summary

- “True” Telerobots are being realized.
- There is hope for improving the effectiveness of remote operations in complex environments.
- Ongoing research will continue to drive this trend.
Thank you for your attention!