Design the HCI Interface Through Prototyping for the Telepresence Robot Empowered Smart Lab

Ramona Plogmann, **Qing Tan,** Frédérique C. Pivot

Athabasca University
Canada

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Outline

- ✓ Telepresence Robot Empowered Smart Lab (TRESL)
  - The System Concept
  - The Service Modules
  - The Mock-up Lab
  - The Research Proceeding
- ✓ HCI Interface Prototyping
- ✓ Remarks

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Telepresence Robot Empowered Smart Lab (TRESL)

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TRESL: *The System Concept*

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The System Overview

- Telepresence robots avatars: the first-person experience
- Telepresence robots, lab devices and equipment, and sensors in the remote laboratory: the mesh network of the Internet of Things (IoT)
- Human-Computer Interaction: VR/AR/MR
- Human-in-the-Loop Cyber-Physical System (HiLCPS)
- Computational Modules: Support features and functionalities of the TRESL system




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The System Ultimate Goals

- ”**Being There**”, i.e. experience as if they were presented in the remote lab, and

- “ **Acting There**”, i.e. extend their interactive capabilities, including sensing, communicating, and mechanical capabilities to do lab work and to interact with the lab environment.

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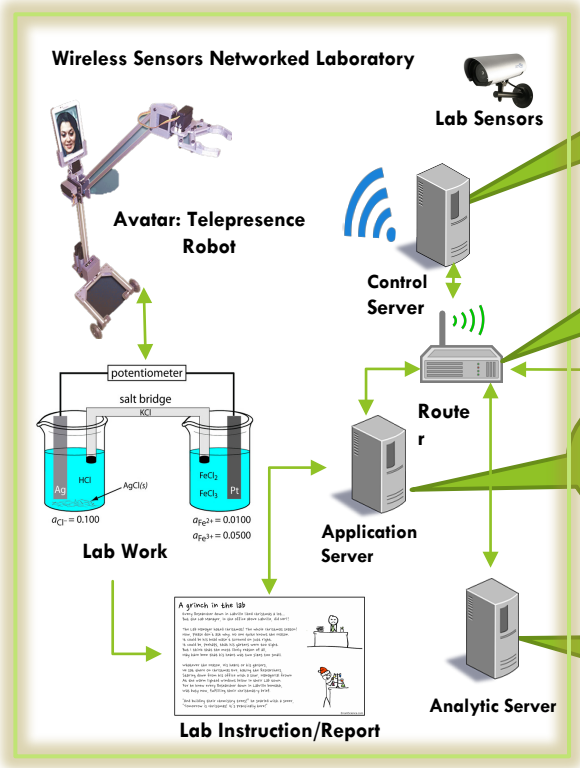
The TRESL System Concept



Control Module
-Telepresence robot
- Sensory network
- IoT Sensors

Security and Privacy Module
-Security Compliance
-Privacy in Design

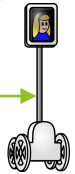
Application Module
-5R Adaptive LMS
-VR, AR, MR
-Cloud Services

Analytic Module
-Learning Analytics
-System Analytics

Online Instructor

HCI Module
-Head Mounted Display
-Joystick
-NLP

Internet



Outdoor Telepresence Robot

Online Students

The ultimate goals of the CPS is to enable an online user

- ✓ Being there – user's psychological feeling
- ✓ Being extended there – user's sensory capabilities and mechanical interactive capability

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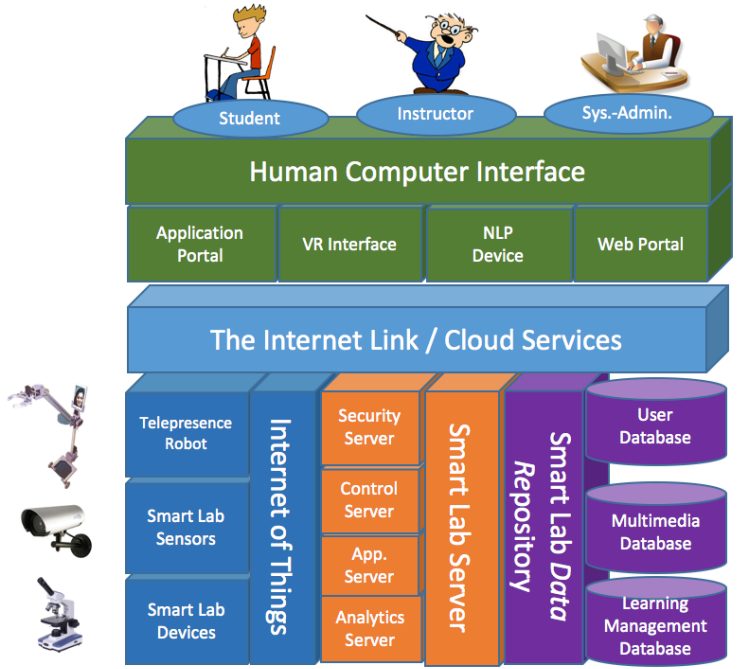
The System Architecture



The Architecture of the Telepresence Robot Enabled Smart Remote Lab

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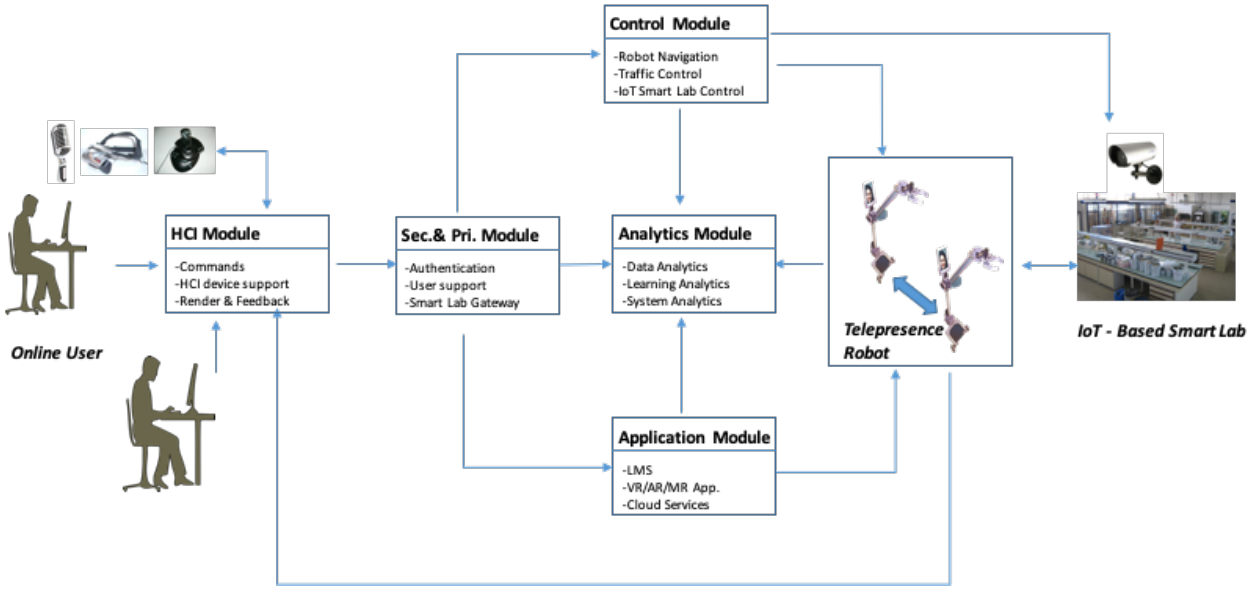
The System Data Flow



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TRESL Pedagogy

- *Standalone:*
  - ✓ *One student using TRESL system independently*
  - ✓ *Do lab work alone*
  - ✓ *24 x 7 available*
- *Collaborative:*
  - ➢ *multiple students at different geographical locations*
  - ➢ *Use the TRESL system at the same time*
  - ➢ *Collaboratively through their robotic avatars to complete lab work together*
- *Blended:*
  - ❖ *At least one student is physically present in the laboratory*
  - ❖ *Work together with at least one robotic avatar towards the same lab or field work*
  - ❖ *Human and robotic avatars are blended together as a group*

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TRESL: *The Service Modules*

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The Security Modules

- The ***Security Module*** runs on the security server at the remote laboratory
- The access point is the first contact point of the local network from/to the Internet. User authentication and authorization will be taken place.
- All traffic entering the smart lab system is traffic for authenticated users
- The confidentiality and integrity of the communication and data exchanged during the application access
- Ensure non-repudiation and log the actions for system analysis and audit.
- User management function will be resided in the security module, data encryption and user privacy protection
- Be accessed via a reverse proxy or network address translation (NAT).

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The Control Modules

- The ***Control Module*** plays the key role in the smart lab system to control the telepresence robot and the smart lab environment.
- To achieve the ultimate experience of telepresence through the robot, the smart lab system allows online users to drive their robots in autonomous mode, manual mode, and leading mode and to easily switch among the control modes through their user interface, ***autonomous mode***, ***manual mode***, and ***leading***
- Enables navigation and positioning services for the robots
- Engages the unique addressable lab devices and equipment (UAHE) to form the local mesh network of the Internet of Things.

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The Application Modules

- The **Application Module** runs on the application server to provide application functionalities and features to the smart lab system.
- Learning Management System (LMS)
- The 5R adaptation
- Simulation and visualization software, provides server services to VR, AR, and MR applications, play video, and run multimedia instructions or demos.
- When the smart lab system provides users as a cloud service, LaaS (Lab as a Service)
- The functionalities and feature as a Cloud Service Provide (CSP).
- Open and flexible to easily add additional applications, functions, and features to the smart lab system.

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The Analytics Modules

- The ***Analytics Module*** is dedicated to the Big Data Analytics (BDA) running on the analytics server
- BDA is used to extract useful information that can be used to enhance online students' learning performance and to improve the smart lab system through the learning analytics and system function analytics
  - Hadoop is a good candidate because it is an open source framework with MapReduce.
  - Apache Spark employs RDDs data sharing abstraction in the analysis of data, which has allowed the engine to perform more tasks including graph processing, machine learning, and streaming.
  - Apache Storm is designed for the analysis of streaming data that are gathered from social media. Its engine is the most preferred in the analysis of unbounded data streams.
  - Apache Flink is capable of analyzing both streaming and historical data

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The HCI Modules

- The ***Human Computer Interface Module*** is installed as the client site application software of the smart lab system and run on the client site computer
- Enable online students or users to interact with the smart lab system with the immersive interaction devices or equipment, such as Head-Mounted Display, VR goggle, joystick, and natural language processing devices.
- Enhance the online users' telepresence experiences, which is not a mandatory component of the smart lab system but by using the module supported it will largely engage online users into the smart lab system to improve their experiences of conducting their lab or filed work online.

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TRESL: Lab Environment

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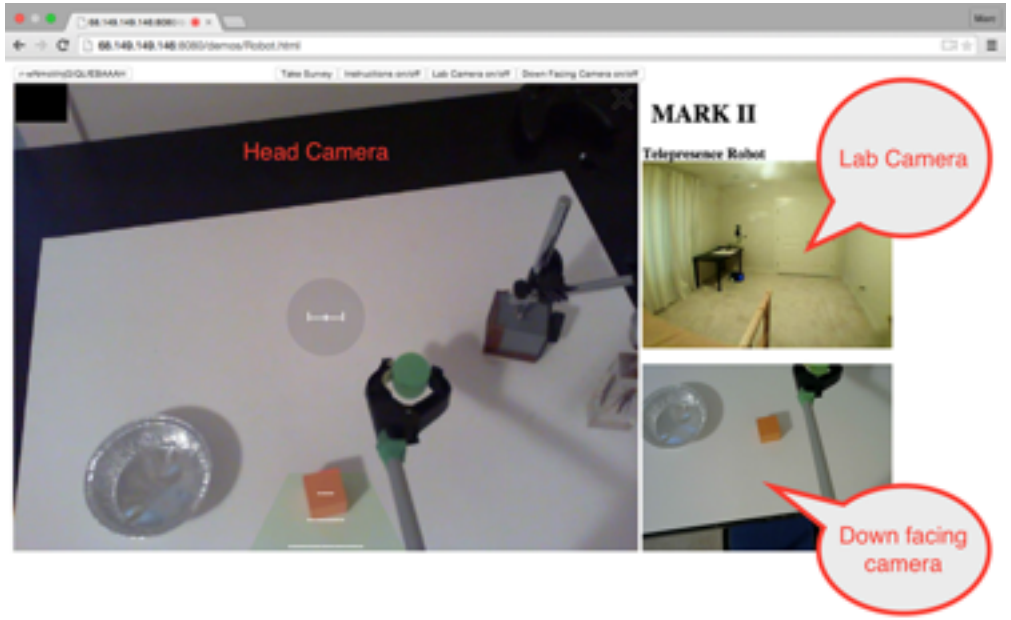
HCI-Interface for the Mock-up Lab



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TRESL: Research Proceeding

- **Overall system**- Being there and being extended there
- **Control Module** – Telepresence robot, IoT, CPS, and WSN
- **Application Module** – Cloud Services, VR, AR, MR, and LMS
- **Analytics Module**-Big Data Analytics, Algorithm, Security and Privacy
- **HCI Module**-HCI devices and Mobile Computing
- **Pedagogy Issues** – Single, Multiple, Blended, and indoor and outdoor lab works
- **Educational** Evaluation and System Validation

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The Research Topics

- **Effective HCI Interface Design through Prototyping for TRESL**
- *Usability Study on TRESL*
- *Model-Based Virtual TRESL Platform - VR/AR/MR Enabled TRESL Simulation Environment*
- *Cloud Robotics for Navigating Multiple Telepresence Robots for TRESL*
- *Machine Learning algorithms to balance Fog and Cloud computing for optimizing TRESL performance*
- *Human-Machine Interaction for the Human-in-the-Loop Cyber-Physical Systems-TRESL*
- *TRESL Framework Design and Algorithm Development*

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HCI-Interface Prototyping

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HCI-Interface Prototyping

Software Tool : **Justinmind**

https://www.justinmind.com

"All-in-one prototyping tool for web and mobile apps
From wireframes to highly interactive prototypes"

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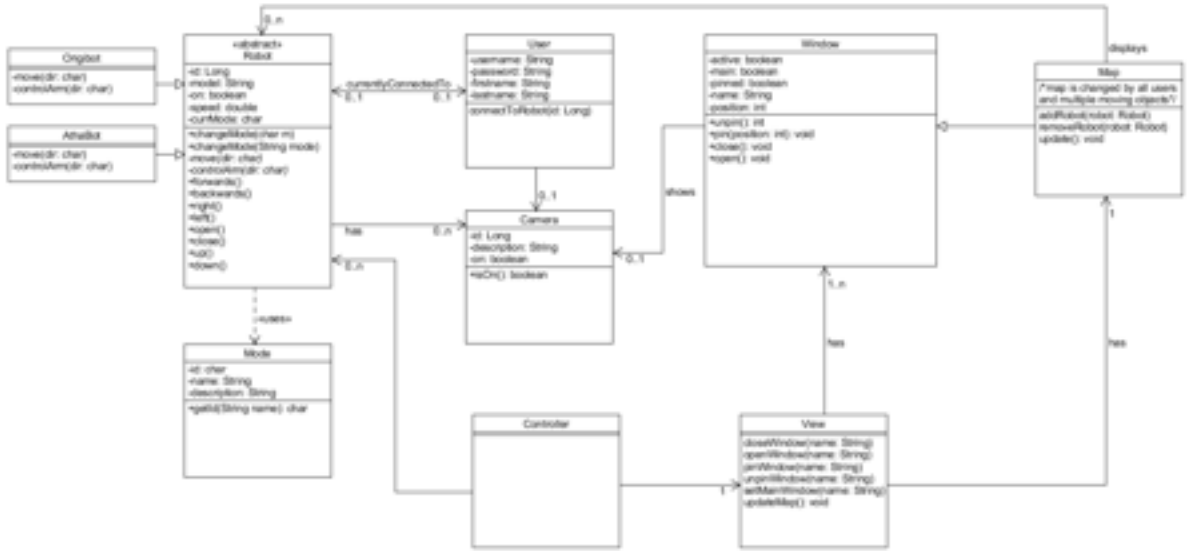
The Structure: The Class Diagram



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Prototype: The Main View

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Prototype: The Menu

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Prototype: The Mutes and Window Menu

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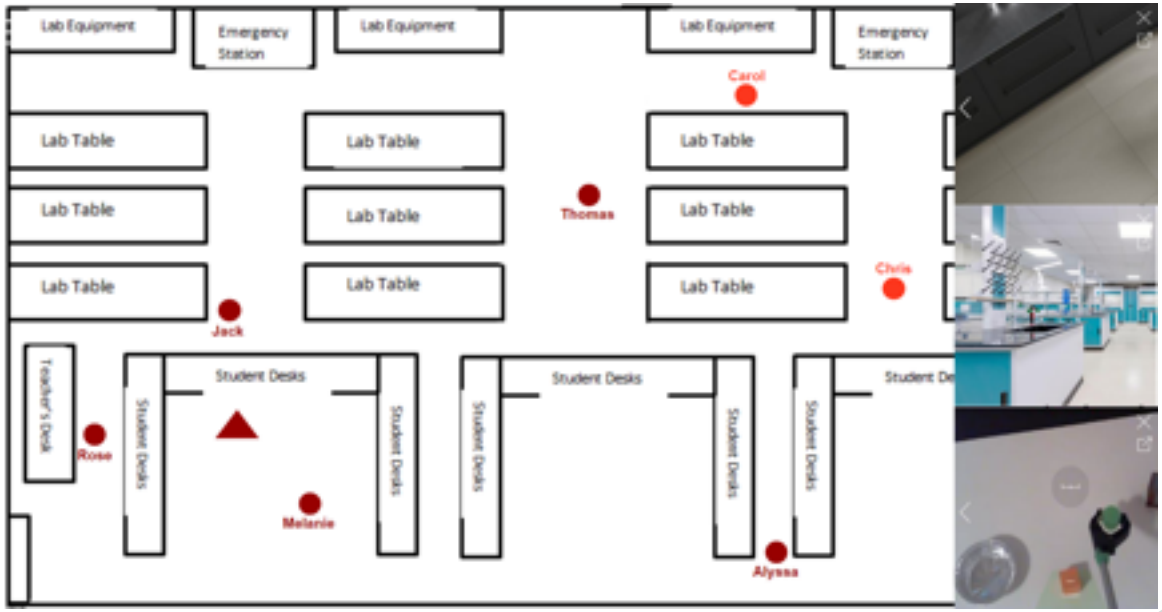
Prototype: The Map



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Scalability

- Through any computer or mobile device
- The keyboard or on-screen controls
- VR/AR/MR – Intuitive and Immersive
- Onsite and Online
- One person or Multiple people

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Remarks

- It needs to develop such system to enable remotely conduct lab work. It is a very complex system
- Involve most of emerging ICT
- The Framework is more important that the system
- ***The Prototyping is intuitive and interactive way***
- ***Cost and time effective way***
- ***Profound Basis for HCI Interface Design***
- ***Further research needed to overcome the limitations***

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Related Publications

- Qing Tan, Marc Denojean-Mairet, Hongxue Wang, Xiaokun Zhang, Frédérique Pivot, and Roland Treu (2019). "**Toward a Telepresence Robot Empowered Smart Lab**". Publication in Smart Learning Environments, (2019) 6: 5.
- Ramona Plogmann, Qing Tan, Frédérique Pivot (2019). "**Design the HCI Interface Through Prototyping for the Telepresence Robot Empowered Smart Lab**". Submitted to 19th International Conference on Intelligent Systems Design and Applications, Pretoria, South Africa, December 3-5, 2019
- Morteza Kiadi, Qing Tan, Jose R. Villar (2019). "**Optimized Path Planning in Reinforcement Learning by Backtracking**". Published in Journal of Current Trends in Computer Science & Applications, Volume 1, Issue 4, July 26, 2019. DOI:10.32474/CTCSA.2019.01.000116
- Morteza Kiadi, Qing Tan (2018). " **Machine Learning: A Convergence of Emerging Technologies in Computing.**" In: Hassanien A., Tolba M., Elhoseny M., Mostafa M. (eds). The International Conference on Advanced Machine Learning Technologies and Applications (AMLTA2018), Cairo, Egypt, February 22-24, 2018
- Marc Denojean-Mairet. (2015)." **Telepresence Robot Enable Remote Lab in Distance Education**", MScIS thesis, Athabasca University, December 2015
- Marc Denojean-Mairet, Qing Tan, Frédérique Pivot & Mohamed Ally. (2014). "**A Ubiquitous Computing Platform - Affordable Telepresence Robot Design and Applications**". Published in the proceeding of the 13th IEEE international Conference on Ubiquitous Computing and Communications, Dec. 19-21, 2014, Chengdu, China

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THANK YOU & QUESTIONS