Augmental Robotics – The Future of IoT

A Tele-Health Use Case

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Agenda

Introduction to Augmental Robotics (AuR)

Augmental Robotics Use Case (Tele Health)

Requirements & Challenges

- **Knowledge Representation - The Language for Robots**
  - **Ontology – Language, Semantics & Relationship**
- **Safety, & Trust**
- **Networking & Communication**
  - **Low Latency**
  - **High Throughput**

Current Standardization Efforts

Conclusions

Introduction

Augmental Robotics –

Future of IoT

Robots perform certain tasks to improve the human efficiency and reduce human errors.

Robots co-exist, and augment humans to enhance their capability in performing certain tasks.

Robots are able to infer their environment and take their autonomous decisions.

Robots are augmenting humans not replacing them !

Use Cases – Tele Health (Tele-diagnosis and Tele-surgery in remote areas), Industry 4.0.

Augmental Robotics (Scenario-1)

Robots Working standalone

- Robots pre-programmed to give instructions.
- Robotic arm carrying out a standard task based upon the instruction and data fed to it.
- Requires continuous instructions and monitoring by humans!

Image Ref: http://www.smithsonianmag.com/innovation/10-ways-tech-makes-old-age-easier-1840093/ and http://www.pinsdaddy.com/robots-used-in-the-medical-field_T8MfBwZ18F8IC088OqCongPuUBI91S39IcbOB29J%7CnQ/

Augmental Robotics (Scenario-2)

Robot to robot collaboration

- **Tele diagnosis and Tele Surgery**
  - **Robots are able to provide haptic feedback to the remote expert !**
- **Perform a specific task based on static instruction and supervision by humans !**

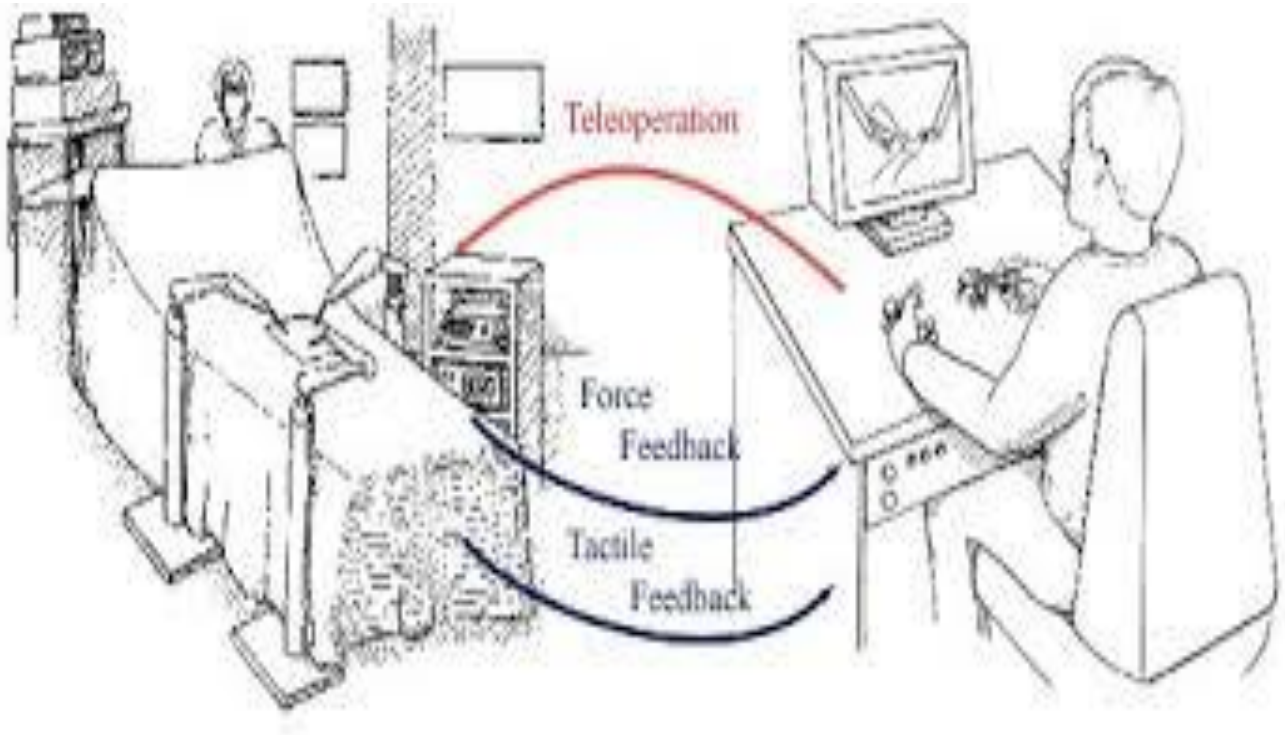


Image Ref: http://i-heart-robots.blogspot.in/2007/03/robotic-telesurgical-workstation-for.html and http://www.1pezeshk.com/archives/2014/10/10-crazy-jobs-that-will-exist-in-the-future.html

Augmental Robotics (Scenario-3)

Robots to Human Collaboration

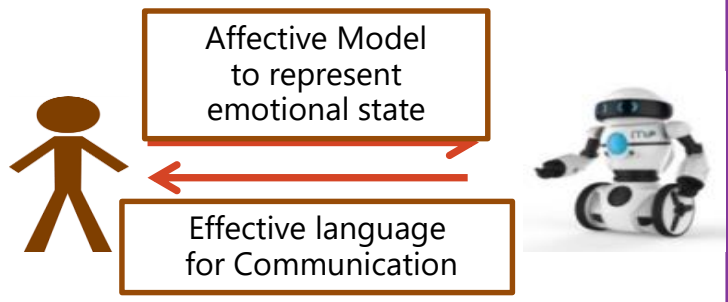
- Robots and Humans are lifting another person together
- Robot is able to understand and react to various emotions.
- **Robots and humans need to understand and interact with each other!**

Image Ref: spectrum.ieee.org and http://www.itp.net/598481-japans-softbank-plans-to-sell-personal-robot-servants

Requirements & Challenges

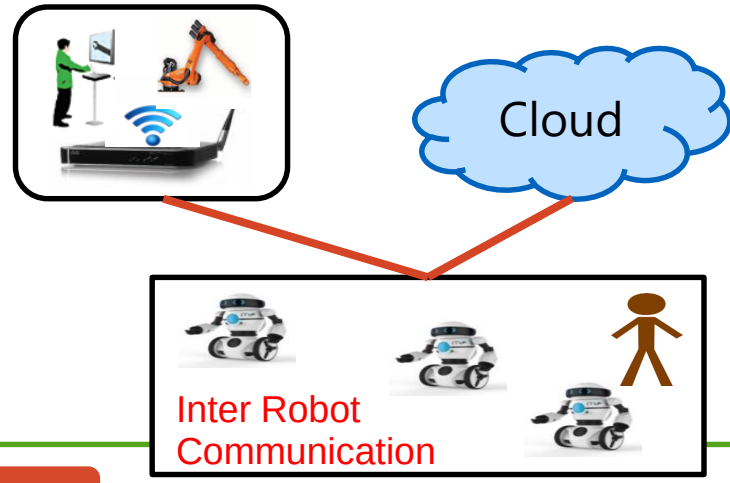
Knowledge Representation

- **Unified representation of learning, emotions, senses is essential.**
- **Unambiguous sharing of information and interoperability among robots and robot to human is critical !**



Networking & Communication

- **Different types of data with different QoS requirements – e.g. Telematics, Control, Perception.**
- **Co-existence and interoperability of multiple heterogeneous devices and communication technologies.**
- **Should be able to provide all of above using public infrastructure !**



Safety and Trust

- **The operating environment must be safe for humans.**
- **For human-robot collaboration, the robotic system must be utmost trustworthy.**

AuR Challenges – Knowledge Representation

Robots and Humans need to understand each other

- What is Knowledge ?
- How that can be represented, stored, retrieved and exchanged efficiently ?
- Understanding of Robots by the Humans makes it even more challenging !

Semantically connected Knowledge Representation

- Robots must autonomously learn, represent and adapt to the knowledge.
- Requires semantic link between knowledge items.
- Must be able to share this knowledge with peers.
- Real Time is the key !!

Image Ref: https://hci.sbg.ac.at/outputs/robot-programming/ and https://ichef-1.bbci.co.uk/news/1024/media/images/60183000/jpg/_60183578_robotandrory.jpg

AuR Challenges – Safety and Trust

Need to re-define the safety and trust for collaborative environment

In such environment, Guidelines are required for

- **Monitoring and Action**
- **Hand and Facial Guiding**
- **Speed and Distance handling**
- **Force, Power and Thrust**
- **Additional safety and fault tolerance in the system to safeguard the human colleague is of paramount importance !**

AuR Challenges – Networking

Diversity in Communication Requirements

- Diverse QoS, Latency, Bandwidth and Reliability requirements.
- Interoperability of diverse technology and devices.

Current Network infrastructure is not apt for Reliable, High bandwidth, Low Latency machine type communication

- For complete AR/VR applications BW : ~1-5 Gbps, End-to-end latency : <5ms.

Machines and Humans operate in different timescales

- Order of difference from 100s of milliseconds to fraction of milliseconds.

Limits are imposed by Physics on the distances

- Can not be more than 150 Km for end-to-end latency of 1ms.

Can this be run on Public Network infrastructure ?

- **Essential for developing Nations like India.**
- Introduces additional challenges of scale, infrastructure, scheduling, fairness etc.

AuR – Standardization Effort

Ontology should be able to represent the aspects of

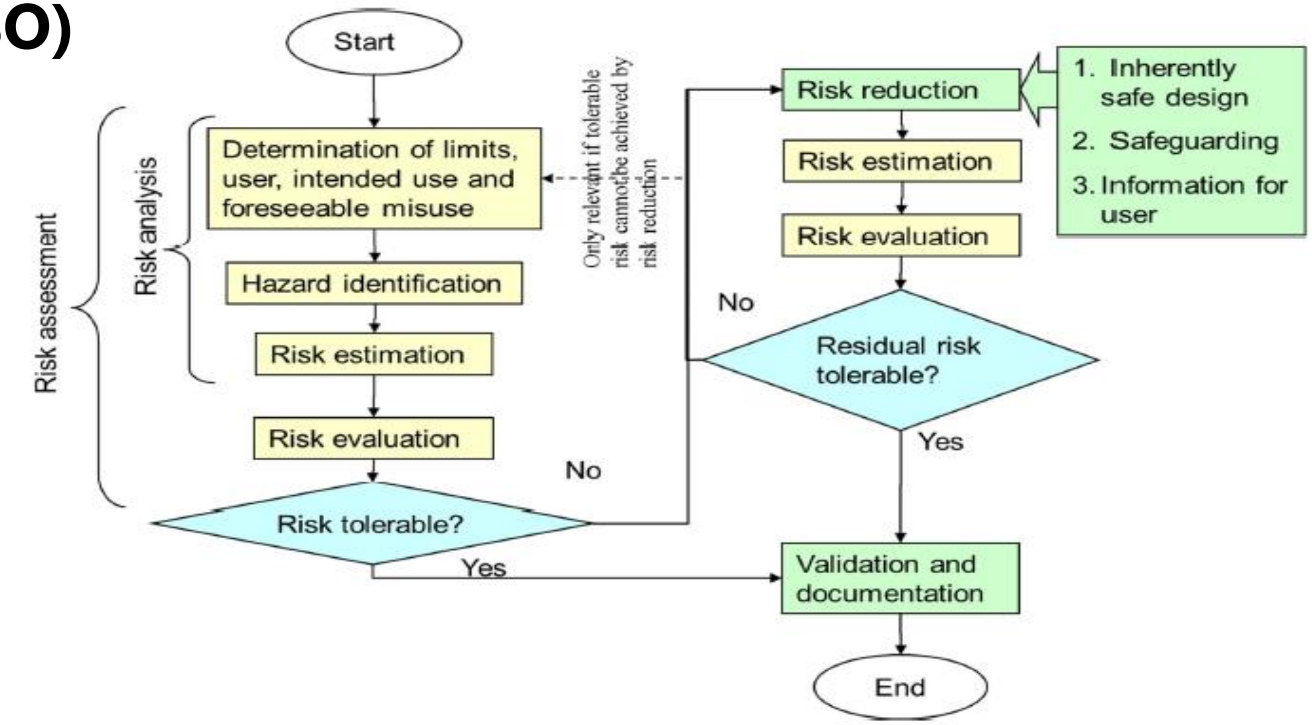
- Knowledge about environment and planning for the same
- Understanding of human colleagues and other co-workers based upon their capabilities
- Must be able to represent gestures, signs and expressions of human colleague

Still an open area of research

- **IEEE Standard Ontologies for Robotics and Automation (IEEE SA - 1872-2015)**
- **Thing-to-thing research group at IRTF (t2trg)**

Guidelines For Industrial Robotic Environment

- **Multiple standards related to Industrial Robotics by International Organization for Standardization (ISO)**
  - **ISO 10218-1:2011**
  - **ISO 10218-2:2011**
- **Different types of environment has different safety requirements**
- **Provides classification for various Safety Hazards**



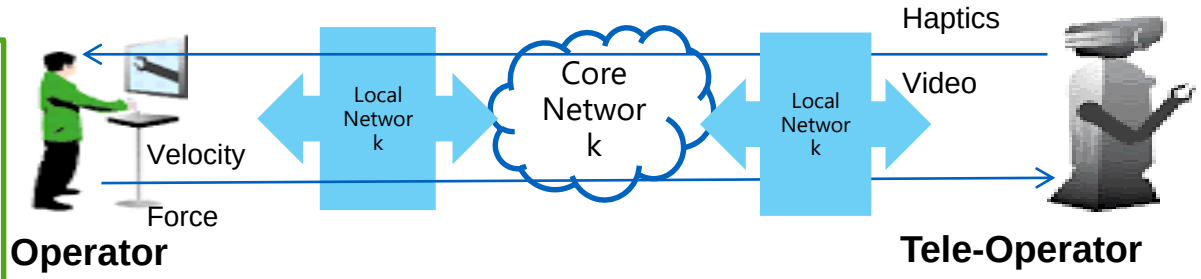
More elaborate Safety guidelines to be defined for co-existence of robots in Social Environment !

AuR Standardization – Networking

Multiple Ongoing Standardization efforts to support AuR use-cases !!

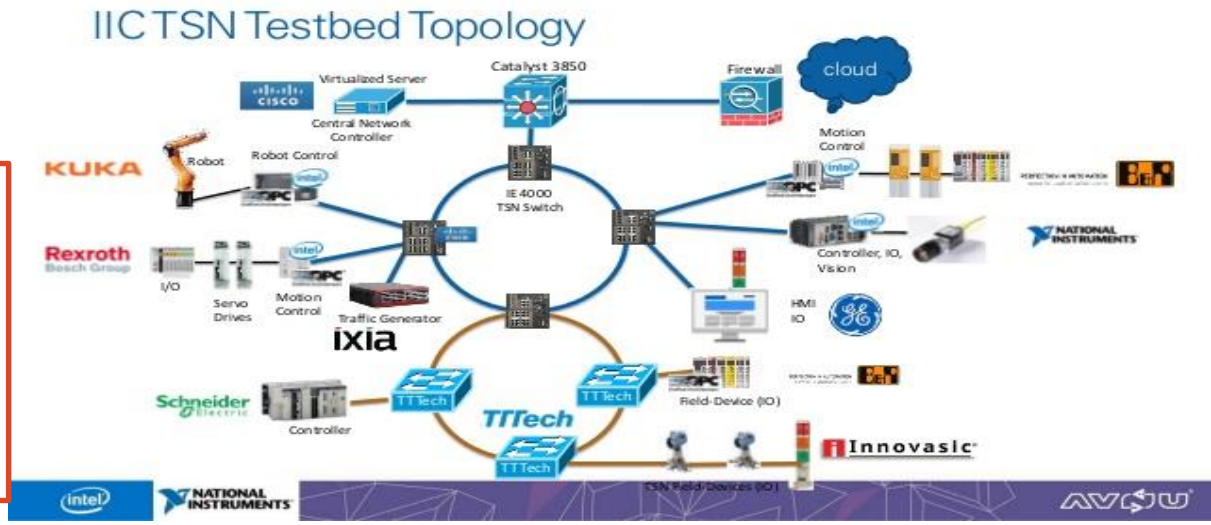
IEEE Standards Association

- P1918.1 - Tactile Internet
- Haptic Codecs for Touch, Feel and sense.
- Decrease volume and Increase reliability.



IEEE 802.1 – Time Sensitive Networking (TSN)

- TSN standards are developed for low latency and deterministic communication to satisfy future industry requirements for L2 devices.
- Industrial Internet Consortium (IIC) has developed a testbed.



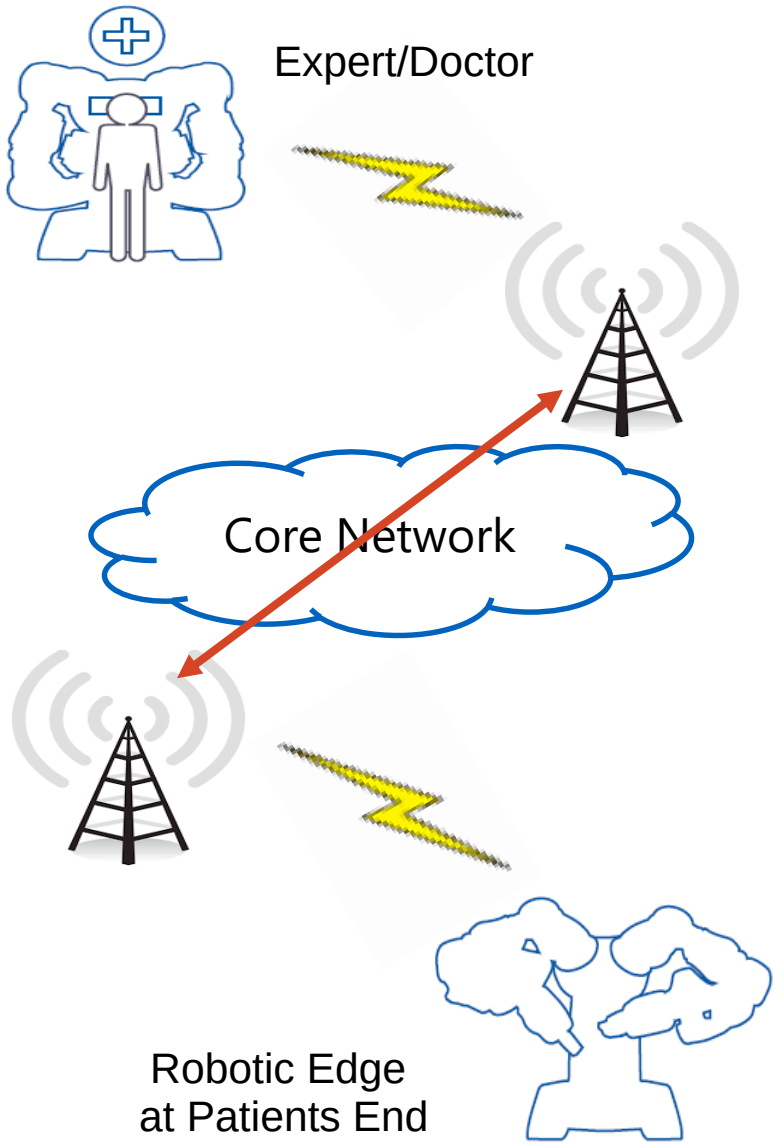
AuR Standardization – Networking

Deterministic Networking (DetNet) – IETF

- **Target to provide time synchronization of 1 µs.**
- **Extraordinarily low Packet Error Rate (10^{-8} or better).**
- **Guaranteed end-to-end latency and bounded jitter.**
- **Dynamic reliability and resource reservation based upon the application context !**

3GPP/TSDSI – AuR use-cases for 5G and beyond

- **Multiple Working groups focusing on different aspects of 5G !**
- **For developing geographies like India Tele-health is one of the most promising use-case.**
  - More than 1.3 billion population with 60% without access to basic healthcare.
- **Frugal 5G has been proposed to connect remote areas in India.**
  - Requires high bandwidth (several Gbps), Low latency (<5ms), Low PER ($<10^{-7}$) and ultra high reliability (<3.5 sec of outage per year).



Concluding Remarks

- Augmental Robotics is penetrating every aspect of life.
- Critical requirements and KPIs such as semantics, latency, data priority etc. need to be defined before Augmental Robotics to be feasible.
- Challenges of representation of Human Senses and Emotions require significant research.
- Standardization is essential for interoperability of heterogeneous devices and technologies.
- Various aspects of Computing, Privacy, Security etc. need to be addressed and standardized !
- Developing Countries like India poses unique challenges of infrastructure, cost and scale !!

Thank you !!!

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