Augmental Robotics – The Future of IoT
A Tele-Health Use Case

Dr. Samar Shailendra
TCS Research & Innovation
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

3rd oneM2M Industry Day hosted by TSDSI
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<th>Augmental Robotics – Future of IoT</th>
<th>Introduction</th>
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<td>Robots perform certain tasks to improve the human efficiency and reduce human errors.</td>
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<td>Robots co-exist, and augment humans to enhance their capability in performing certain tasks.</td>
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<td>Robots are able to infer their environment and take their autonomous decisions.</td>
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<td>Robots are augmenting humans not replacing them!</td>
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<td>Use Cases – Tele Health (Tele-diagnosis and Tele-surgery in remote areas), Industry 4.0.</td>
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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!

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!

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!

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!!

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.
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:

- 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.
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 !!!
s.samar@tcs.com