TOWARDS A PROTOCOL FOR COMPUTATIONAL INTELLIGENCE AS A SERVICE

W3C TPAC 2023

USE CASES AND REQUIREMENTS

OVERVIEW

Operator	System	Use Cases
Human	Physical robot	Telerobotics
Human	Virtual avatar	Virtual presence
Artificial intelligence	Physical robot	Robotics, Cloud robotics, Fog robotics
Artificial intelligence	Virtual avatar	Videogame AI, Simulation, Evaluation

TELEROBOTICS

A protocol would be useful for connecting human operators and instrumentation to robots.

VIRTUAL PRESENCE

A protocol would be useful for enabling virtual presence.

End-users could consume audio and video streaming data from virtual environments and have their motion translated into control signals for virtual characters or avatars.

ROBOTICS

A protocol would be useful for connecting AI systems to robots.

CLOUD ROBOTICS

Cloud robotics is a field of robotics that attempts to invoke cloud technologies such as cloud computing, cloud storage, and other Internet technologies centered on the benefits of converged infrastructure and shared services for robotics.

When connected to the cloud, robots can benefit from the powerful computation, storage, and communication resources of modern data center in the cloud, which can process and share information from various robots or agents.

FOG ROBOTICS

Fog robotics mainly consists of fog robot servers and the cloud. It acts as a companion to cloud by shoving the data near to the user with the help of local servers.

Moreover, these servers are adaptable, consists of processing power for computation, network capability, and secured by sharing the outcomes to other robots for advanced performance with the lowest possible latency.

VIDEOGAME ARTIFICIAL INTELLIGENCE

A protocol would be useful for future videogames where creatures and non-player characters would not have to all be run on one videogame console or computer.

SIMULATION

A protocol would be useful for the training of AI systems.

Downloading training systems and/or uploading AI systems may be infeasible.

Both might be run on the cloud (potentially different clouds) and communicate via a protocol.

A robotics simulator, for example, is a simulator used to create an application for a physical robot without depending on the physical machine, thus saving cost and time. In some case, such applications can be transferred onto a physical robot (or rebuilt) without modification.

EVALUATION

A protocol would be useful for the testing of AI systems.

Downloading testing systems and/or uploading AI systems may be infeasible.

Both might be run on the cloud (potentially different clouds) and communicate via a protocol.

AI systems can be evaluated on multiple activities simultaneously and in parallel.

Evaluations can utilize multiple copies of a single agent or multiple different agents. Evaluations might involve artificial ecosystems.

Evaluations of AI systems can be adaptive.

DISCUSSION

OVERVIEW

The contents, or payload, of the protocol are envisioned as being comprised of sensor data, transmitted in one direction, and control signals, transmitted in the other.

Additionally, a higher level of abstraction can be considered where robots and digital avatars could present their AI operators with recognized objects, their affordances, and other available actions, and receive selected actions or plans.

SENSOR DATA

Sensor data could be streamed from physical robots or virtual avatars to operators.

Types of physical sensors utilized in robotics include: 1D range finders; 2D range finders; 3D sensors (range finders & RGB-D cameras); audio and speech recognition; cameras and optical sensors; environmental; force/torque/touch sensors; motion capture; pose estimation (GPS/IMU); power supply; RFID; speed.

See: http://wiki.ros.org/Sensors

Many of these sensor types can be virtualized or simulated.

CONTROL SIGNALS

Control signals, e.g., to actuators, could be streamed from operators to physical robots or virtual avatars.

DYNAMIC PLANNING DOMAINS

Above the level of abstraction of actuators, physical robots and virtual avatars could present operators with data including (dynamic) planning domains presenting instantaneously recognized objects, their affordances, and other available actions.

For example: {move left, move right, move forward, move backward}.

TIME SYNCHRONIZATION

The synchronization of time across robots and computing nodes.

See: https://webtiming.github.io/timingobject/

REMOTE PROCEDURE CALLS AND ORCHESTRATION

For an example of a remote procedure call, a computer aboard a robot might route audio stream contents to a fog computing node and receive a speech-to-text transcription.

For an example of an orchestration, a computer aboard a robot might route two synchronized video tracks from two video camera sensors to a remote fog computing node which could process these video tracks into a synchronized output stereoscopic depth video track and subsequently stream the two input video tracks and resultant depth track to another fog node for further computer vision processing.

ROBOT-TO-ROBOT COMMUNICATION

A protocol could enable robot-to-robot communication scenarios.

EXTENSIBILITY

A protocol could support an extensible set of semantically-labeled and annotated data and multimedia tracks.

In this way, developers using a protocol could easily build producers and consumers of new kinds of tracks, e.g., a new type of sensor data.

RELATED TECHNOLOGIES

Related technologies include, but are not limited to, protocols for: audio and video streaming, cloud gaming, virtual presence and mixed-reality, WebRTC, IoT and WoT, cloud and fog robotics, and space-program robotics and telerobotics.

SMARTNIC

In the future, smart network interface controllers (SmartNIC) could offload and handle the processing of codecs and protocols including those under discussion.

Sequences and deltas of primitive datatypes, vectors thereof, 1D/2D/3D arrays or textures, point clouds, and other data for extensible tracks, could be transferred from CPU/GPU RAM, via DMA, to SmartNIC devices, encoded and then transmitted across networks.

SmartNIC hardware could, similarly, decode the tracks of streaming protocols and utilize DMA to place incoming data into CPU/GPU RAM buffers and notify software as data were received.

CONCLUSION

QUESTIONS

Which existing standards, e.g., WebRTC, could be useful for enabling new computational-intelligence-as-a-service scenarios?

CONCERNS

Bandwidth limitations, latency, quality of service, privacy, and security.

HOPES

A new protocol could spur innovation and enable new computational-intelligence-as-a-service scenarios.

THANK YOU

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