AmIIoTE: Ambient Intelligence in Internet of Things Environments

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***Abstract*—Many digital devices (mobile or embedded) appear near people due to the Internet of Things (IoT). Such a device can be utilized to serve humans. Devices enable cooperative service construction. Any IoT environment can be considered as a smart or intelligent environment, since the goal is to produce smart services for its users. In the AmIIoTE special track, we consider four proposals on smart service development for IoT environments: a) Fault Diagnosis for Industrial Rotary Machinery based on Edge Computing and Neural Networking. b) Robotic and smart service for people with disabilities. c) Edge-Centric Video Data Analytics for Smart Assistance Services in Industrial Systems. d) Automated Code Generation of Multi-Agent Interaction for Constructing Semantic Services.**

***Keywords*–Ambient Intelligence, Internet of Things, Smart Service, Edge-Centric Computing, Robotics**

I. Introduction

Smart service is characterized by such properties as context-awareness, personalization, information assistance, ubiquitous access, adaptation, pro-active delivery, and others. Service intelligence can be created based on the Ambient Intelligence (AmI) [1].

An Internet of Things (IoT) environment provides multi-source data and sensing possibilities. Data sources are people, information systems, Internet services, smart IoT objects, and embedded and mobile sensors. The data are fused and analyzed to derive the proper information to assist the user.

This data-centric property leads to the Tactile Internet [2]. The term broadly refers to a communication network that is capable of delivering real-time control, touch, and sensing/actuation information through sufficiently reliable, responsive, and intelligent connectivity.

With the AmIIoTE Special Track, submissions were invited with original research or review work focused on the Ambient Intelligence and Internet of Things environments. Research and development topics include but were not limited to:

- Smart IoT technologies, platforms, and systems;
- Digital devices and network components for creating AmI in an IoT environment;
- Multisource data sensing and information exchange in an IoT environment;
- Fusing data from physical, cyber, and social worlds;
- Edge and Fog computing for IoT environments;
- Data mining by interaction of many IoT devices;
- Data analytics based on semantic relations discovered in multisource data;
- AmI implementation as a service of information assistance;
- Testbeds, applications, case studies, and social issues around creating AmI in an IoT environment.

II. Problem

The data analysis is almost in real-time, when shared data are dynamically updated. Advanced solutions are needed to access up-to-date information. The top relevant information facts are found among many appropriate ones. Advanced solutions to the information ranking problem are needed to efficiently assist the user. Plenty of different multimedia and mobile equipment are used to effectively deliver services as assistance information to users.

In this respect, we considered the following open problems to study.

- Services provide analytics in real-time using edge IoT devices.
- Applying AI methods to robotic movement analysis with very fast response.
- Assistance services based on event recognition in video data.
- Programming smart services for IoT environments as an information system of agents.

Each of the identified open problems was discussed within own submission to the AmIIoTE Special Track, as presented in Section III further.

III. Submitted Proposals

In total, four papers are submitted.

- Fault Diagnosis for Industrial Rotary Machinery based on Edge Computing and Neural Networking [3].
- Robotic and smart service for people with disabilities [4].

- Edge-Centric Video Data Analytics for Smart Assistance Services in Industrial Systems [5].
- Automated Code Generation of Multi-Agent Interaction for Constructing Semantic Services [6].

A. Fault Diagnosis for Industrial Rotary Machinery based on Edge Computing and Neural Networking

This work studies the problem of real-time analytics on the IoT edge (for a particular application domain in Industrial IoT). Recent progress in Sensorics and Internet of Things (IoT) enables real-time data analytics based on data from multiple sensors covering the target industrial production system and its manufacturing processes. Diagnostics and prognosis can be implemented using the neural network approach on top of vibration and other sensed data.

On one hand, neural network methods lead to high accuracy in fault detection and fault evolution. On the other hand, transferring a neural network model to edge devices leads to performance issues and platform limitations. Discussion is provided on the edge computing opportunities for diagnostics of industrial rotary machinery using well-known neural network methods.

B. Robotic and smart service for people with disabilities

This work studies the problem of effective applying AI methods in robotic systems (for a particular domain of developing the robotic system for the care and supervision of people with disabilities). The main functions of the robotic system are telecommunications between patient and his guardian, automatic management of platform movement, manipulator movement and gripper.

An overview of existing solutions (devices) on the robotics market that implement similar capabilities is presented. In order for a robotic system to be widely accessible to all people, it is necessary to reduce the cost of its components. Inexpensive mechanical components have disadvantages in terms of movement accuracy.

The hypothesis is about the possibility of using artificial intelligence to improve the accuracy of actions performed by a robotic system. In particular, analysis of the video image of the manipulator movement can allow to adjust the speed and angle of rotation of the motors in the joints of the manipulator, thereby making the movements more accurate.

C. Edge-Centric Video Data Analytics for Smart Assistance Services in Industrial Systems

This work studies the problem of development of smart assistance services based on applying AI methods for video data streams (for a particular application domain in Industrial IoT). Video data analytics become now essentially oriented on Edge-Centric computing in Internet of Things (IoT).

The authors consider video services that provide analytics to smart assistance in industrial IoT systems. They identify the opportunities of industrial video data analytics. They present an edge-centric architecture for constructing smart assistance services.

Based on this architecture, the authors implemented several pilot services that demonstrate the opportunities of industrial video data analytics. The services are deployed and experimented in a real enterprise for monitoring industrial production equipment (technical state and its evolution, ongoing production processes, equipment operating conditions).

D. Automated Code Generation of Multi-Agent Interaction for Constructing Semantic Services

This work studies the problem of rapid development of smart services based on semantics of information-driven interaction in IoT environment. The proposed approach simplifies the development and maintenance of smart space applications by creating tools for automated code generation of multi-agent interaction for constructing semantic services.

The general scheme of automated code generation process of multiagent interaction for constructing semantic services is introduced. By expanding the OWL-S ontology, a unified ontological description of the semantics of service constructing processes is introduced. The code generation procedures for agent data object model and interaction processes are presented.

The efforts in automated development of semantic services through the use of the proposed unified service ontology and the code generator are investigated based on estimation of time to generate program code and the quality metrics of generated code.

IV. Conclusion

This Special Track considered four papers. Each paper studied an important open problem of creating AmI in IoT environment.

Problem 1: Services provide analytics in real-time using edge IoT devices. Work [3] experimented with the fault diagnosis problem for industrial rotary machinery based on edge computing and neural networks.

Problem 2: Applying AI methods to robotic movement analysis with very fast response. Work [4] discussed the opportunities and challenges of robotic and smart service for people with disabilities.

Problem 3: Assistance services based on event recognition in video data. Work [5] demonstrated perspective smart assistance services for edge-centric video data analytics in Industrial Systems.

Problem 4: Programming smart services for IoT environments as an information system of agents. Work [6] introduced an approach of automated code generation of multi-agent interaction in IoT environment when the agents cooperatively construct semantic services.

Special Track Chair

Dmitry Korzun received his B.Sc. (1997) and M.Sc (1999) degrees in Applied Mathematics and Computer Science from the Petrozavodsk State University (PetrSU, Russia). He received a Ph.D. degree in Physics and Mathematics from the St.-Petersburg State University (Russia) in 2002. His educational activity started in 1997 at the Faculty of Mathematics of PetrSU (now Institute of Mathematics and Information Technology). He is an Adjunct Professor at Department of Computer Science of PetrSU (since 2003 and ongoing).

He was a Visiting Research Scientist at the Helsinki Institute for Information Technology HIIT, Aalto University, Finland (2005-2014). In 2014-2016 he performed the duties

of Vice-dean for Research at Faculty of Mathematics and Information Technology of PetrSU. Since 2014 he has acted as Leading Research Scientist at PetrSU, originating research and development activity within fundamental and applied research projects on emerging topics in ubiquitous computing, Internet technology, and Ambient Intelligence. Since 2019 he is head of Data Mining Lab at PetrSU.

Dmitry Korzun serves on technical program committees and editorial boards of 100+ of international conferences and journals. He is an author and co-author of 200+ research and educational publications. He published several monographs in Springer and IGI Global. He serves as Guest Editor of special issues in scientific journals.

Dmitry Korzun is UBICOMM TPC member since 2011. He made presentations at UBICOMM in 2010, 2015, 2016, 2020.

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