Intelligent Urban Environment Lab Infrastructure Design

Toma Tomov [1], Ioannis Patias [1] and Vasil Georgiev [1]

[1] *University of Sofia "St. Kliment Ohridski", Faculty of Mathematics and Informatics, 5 James Bourchier blvd., Sofia, 1164, Bulgaria*

Abstract

MIRACle (Mechatronics, Innovation, Robotics, Automation, Clean technologies) project refers to the Establishment and development of a Center for Competence in Mechatronics and Clean Technologies. The specific activities for the Laboratory Intelligent Urban Environment require the deployment of a modern infrastructure. The main design goal was that the infrastructure should support both real-time and in batch data, various database management systems, and sensor types. In this paper, the focus is on the infrastructure design. In this paper, we present the generic infrastructure model that is under development in the IUE-Lab as planned to cover the related activities and use cases.

Keywords

Intelligent public environment, intelligent home environment, intelligent personal assistant, research and development, infrastructure

1. Introduction

Given the importance of infrastructure for the success of any newly established laboratory, we aim to adopt existing best practices, maximize the potential, and achieve innovation at scale. The main idea is to start the deployment of the infrastructure based on a clear strategy. Thus, any efforts will not stop to small pilots, and fail to further scale up and achieve significant impact. Efforts will be invested to design pilots and other projects with an end-to-end approach, and incorporation of all the necessary elements for successful implementation. In addition, of course in this direction our relations with the business play an important role. [1, 3]

Now days, data driven research and development (R&D) needs to both take advantage of data, but also try and connect cross-sector players, and opportunities. Vertical development in a sector is no longer enough; now R&D labs must be

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EMAIL: tomat@uni-sofia.bg (T. Tomov); patias@fmi.uni-sofia.bg (I. Patias); v_georgiev@fmi.uni-sofia.bg (V. Georgiev)
ORCID: 0000-0002-6307-8409 (T. Tomov); 0000-0003-1355-7433 (I. Patias); 0000-0003-3291-1274 (V. Georgiev)

cross-sector. Development of expertise on specific functions, and expanding this expertise over and above specific sector expertise, is the key question.

MIRACle (Mechatronics, Innovation, Robotics, Automation, Clean technologies) project refers to the Establishment and development of a Center of Competence (CoC) in Mechatronics and Clean Technologies. It is a research project and a joint effort of advanced institutes in Bulgaria. The Laboratory Intelligent Urban Environment (IUE-Lab) under MIRACLe project will integrate its activities in three different application scenarios in the areas: Intelligent Home Environment (IHE), Intelligent Public Environment (IPE), and Intelligent Personal Assistant (IPA). For the purpose, IUE- Lab requires the deployment of a modern infrastructure.

With all this in mind, we will try to explain how to develop best practices and translate it into impact. In this paper, we will discuss how to design, and develop the right infrastructure for a successful CoC. The specifics of IUE-Lab infrastructure design are discussed. The main design goal was that the infrastructure should support both real-time and batch data collection and storage, in various database management systems, and from different sensor types. [4, 5, 6, 7]

2. Data flow

In the frame of IUE-Lab activities under MIRACLe project, we aim in developing interactions both cross-platform, and cross networks, and include in all those different smart objects. All those should take place in dynamic, scalable, decentralized and intelligent environments of Internet of Things (IoT) elements. Such elements are usable and highly demanded by many sectors including, public sector, home applications, and by quite specific needs, including, vulnerable groups, supported by autonomous interacting intelligent systems and even networks of smart, intelligent, embedded systems [8, 9].

In this direction, the main objectives of the data flow requirements are:

- diversity of data sources;
- secure storage, and testing platforms, and applications;
- compliant to privacy regulations data analysis;
- provision of trustworthy Artificial Intelligence (AI) and machine learning (ML) solutions.

This infrastructure, in terms both of hardware and software, should be able to support the data flow from observational and real-time data collection, storage, analysis, and their further use in applications using AI&ML (see Figure 1).

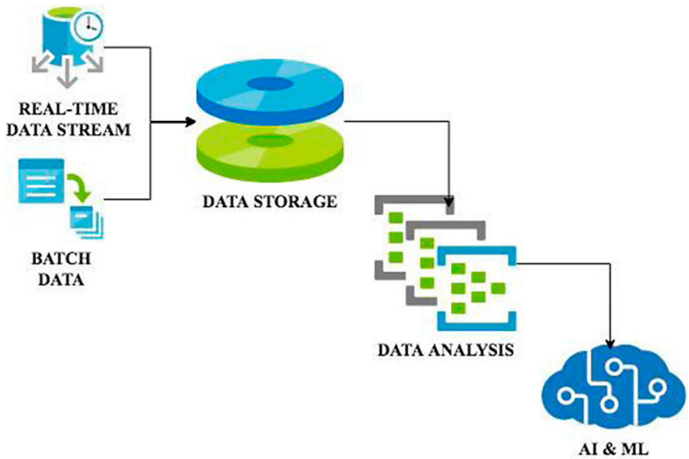

Figure 1: IUE-Lab activities under the MIRACle project

3. Lab activities – use cases

One key limitation of modern autonomous and intelligent systems is that their functionalities are designed and delivered independently. No matter most of the devices are connected to the Internet, they do not coordinate their activities. Their integration is possible, there are IoT platforms, but most of the autonomous and intelligent systems operate in isolation. This is a great loss of the opportunity for the development and the deployment of innovative functionalities and the delivery of new advanced services. The barriers and limitations of such integration of IoT elements and devices with smart autonomous intelligent systems such as robots is the overall focus of IUE-Lab. [10]

IUE-Lab will develop four main activities, or use cases covering a wide range of applications (see Figure 2), namely:

- iVille – mobile (incl. flight) autonomous hub of data and control signals for the urban environment;
- iÉcole – mobile autonomous hub of data and control signals for public structured environment – for example in education and administrative services. Within the IUE-Lab, it will be prototyped for the purposes of the educational environment;
- iVac – mobile autonomous hub of data and control signals for the home environment; and
- iChien – an electronic guide for blind people, based on a smartphone and integration into the IUE.

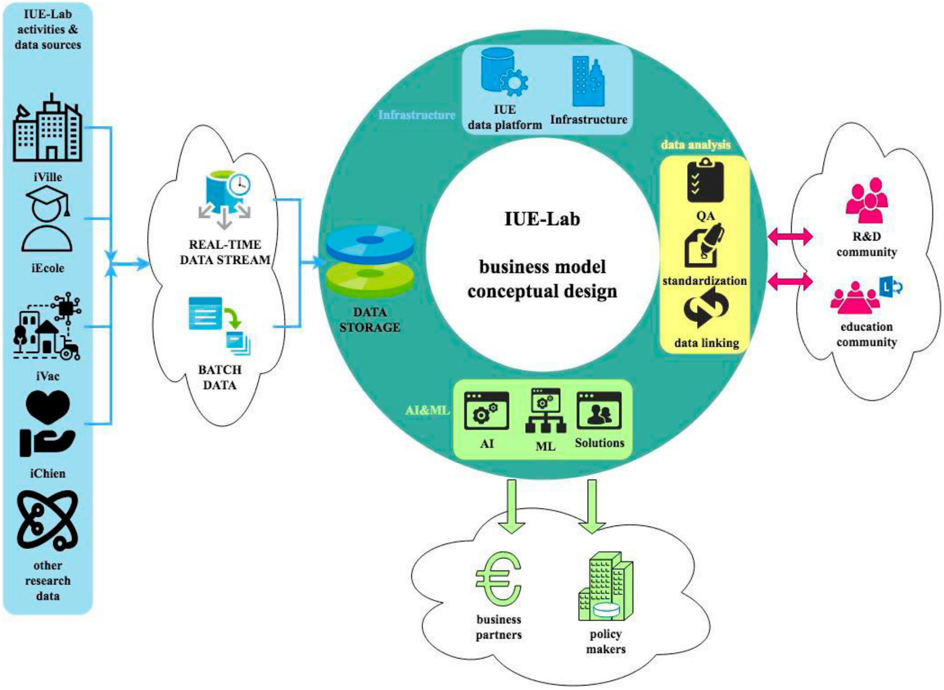

Figure 2: IUE-Lab activities under the MIRACle project

3.1. Ville

The mobile autonomous data and control signals hub for integrated urban environment can be used to cover the respective needs. According to the International Federation of Robotics (IFR) services robots related to integrated urban environment could be used for the delivery of services related to (see Figure 3) [2, 11]:

- Professional cleaning;
- Floor cleaning;
- Window and wall cleaning (incl. wall climbing robots);
- Tank, tube and pipe cleaning;
- Hull cleaning (aircraft vehicles etc.);
- Other cleaning tasks;
- Inspection and maintenance systems;
- Facilities, plants;
- Tank, tubes, pipes and sewers;
- Other inspection and maintenance systems;
- Construction and demolition;
- Nuclear demolition & dismantling;

- Building construction;
- Robots for heavy/civil construction;
- Other construction and demolition systems.

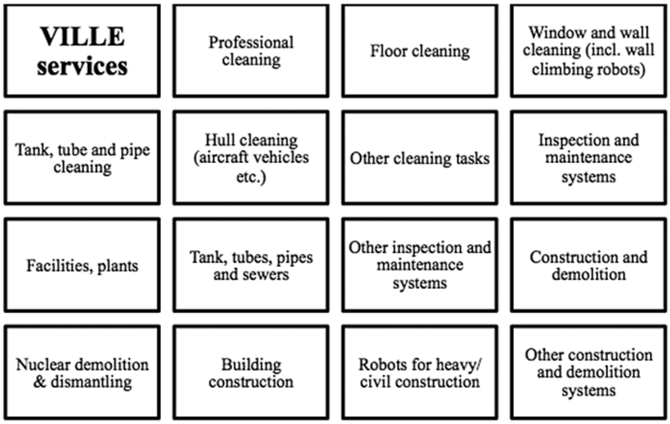

Figure 3: Ville services

3.2. iÉcole

In the same direction the IFR services robots related to public, and other kind of administrative environment could be used for the delivery of services related to (see Figure 4) [2, 11]:

- Robot companions/assistants/humanoids;
- Floor cleaning;
- Window and wall cleaning (incl. wall climbing robots);
- Multimedia/remote presence;
- Education and research.

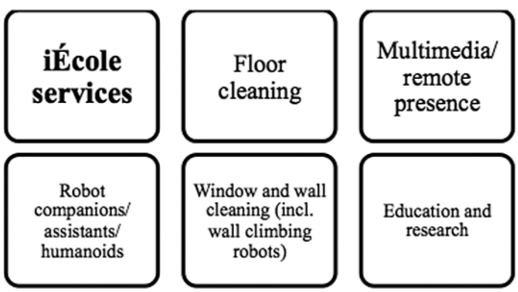

Figure 4: iÉcole services

3.3. iVac

The IFR advices that services robots related to home environment could be used for the delivery of services related to (see Figure 5) [2, 11]:

- Robot companions/assistants/humanoids;
- Vacuuming, floor cleaning;
- Lawn-mowing;
- Pool cleaning;
- Window cleaning;
- Home security & surveillance.

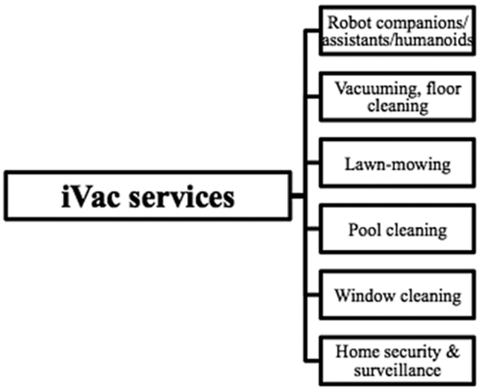

Figure 5: iVac services

3.4. iChien

Finally, the IFR proposes services robots related to the support of people with disabilities, and as an electronic guide for the blind people, based on a smart-phone and integration into IUE could be used for the delivery of services related to (see Figure 6) [2, 11]:

- Robotized wheelchairs;
- Personal aids and assistive devices;
- Other assistance functions;
- Home security & surveillance.

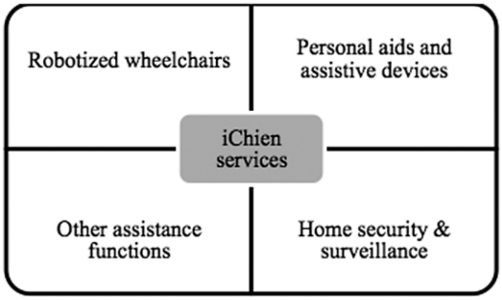

Figure 6: iChien services

4. Design specifics and challenges

Robots performance related data generated by autonomous and intelligent systems is of interest to the researchers from various fields and currently the unification of the access to such data remains a challenge from the scientific community [3]. Consequently, an important issue is whether the data generated in the IUE lab should be provided for use, for example, in research. In such case, it must be clear for which purposes the research community use the data generated in the lab, meaning respective procedures and tools must be in place.

As second challenge was identified whether the participating researchers, generating data will be willing to share their data with other participants from the research community. The development of the infrastructure must have procedures and tools in place for such dissemination of data also.

Third challenge appears to be the quality of the generated data. This covers from one side the question of whether the data are appropriate to be used for the initial purpose, but also whether the design of the data collection model is reliable, meaning whether it covers the requirements described in the data flow model in the previous sections.

However, apart the technological limitations there is also a business related limitation. A sustainable business model must also be part of the infrastructure design aspects. The sustainability of the IUE lab is a key component and in terms of design limitations poses the idea of fragmentation avoidance. All the equipment, data, knowhow and people both at individual and research, and policy environment should be considered as one part, and provided as such.

Finally, the generation and further usage of any data by the robots and the autonomous intelligent systems in the IUE lab involve a wide range of stakeholders. Thus, we need to develop a platform to cover the concrete needs of each stakeholder together with the coordination between all the stakeholders.

5. Conclusions

In this paper, the main design goals for the IUE-Lab were discussed. It was reported the IUE-Lab data flow and management system model. The proposed data management model serves the needs of MIRACle project: Mechatronics, Innovation, Robotics, Automation, and Clean technologies – Establishment and development of a Center for Competence in Mechatronics and Clean Technologies, and more specific for the Laboratory Intelligent Urban Environment. The design goal that the underlying infrastructure should have was described. Based on a generic infrastructure model that is under development the specifics of the IUE-Lab activities and use cases are met.

6. Acknowledgements

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