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Integrated living environment: Measurements in modern energy efficient smart building with implemented the functionality of telemedicine

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ABSTRACT

The paper depicts the metrology as a vivid fundamental science with implications for possible applications in various engineering fields. This depiction uses the energy efficient smart building with embedded the functionality of telemedicine as the example of integrated living environment. State of the art for such issue and object has been reviewed here. Results provided for exemplary CTE's office building show the effectiveness of performance of multisensory measurement network in the task of heating system optimization. These results highlight also the meaning of fusion algorithms in management of complex systems.

Although the building infrastructure described in the paper aggregates a bench of open questions, it moves also the perception to more generalized objects, which can be explained in the context of complex systems, networking science, scaling rules, etc. Proposed attempt has opened the challenges for researchers and engineers in numerous domains. This domains and problems have been denoted and shortly characterized in the paper.

1. Introduction

Management of energy consumption is the leading thread of contemporary civilization. Balanced exploitation of energy resources influences environmental and economic conditions of human life, hence, apart from the political and public actions, various technical solutions are proposed to meet the social and environmental demands. Buildings account for 41% of primary energy consumption in Europe (Fig. 1). 85% of this energy is used for room heating and room cooling as well as 15% for electrical energy (in particular, for lighting). Overall, buildings account for 35% of primary energy use to achieve comfortable temperatures and 6% for electrical energy [1].

Energy efficient smart building is the system which meets the definition of complex system [2,3]. What is more, this subject is the core of the fundamental, modern science. Investigations of the complex systems bring to the various methodological conceptions which further pioneer the technological breakthrough. Complex system involves a huge number of properties and processes, which find their reflection in non-trivial response stated by observer. Initially postulated, the atomistic attempt has assumed three stages in the cognitive process: distinguishing of the small subsystems in the object, description of these subsystems with the use of formal language, and accumulation of knowledge by combination of partial

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knowledge on the subsystems. In this initial methodological attempt, the whole is equal to the sum of its parts. But Aristotle's point of view: 'The whole is greater than the sum of its parts' have changed the modern science, triggering the base for complex, dynamical systems [4]. The observation is the main stage in cognitive process – the main tasks for metrology [5]. Given the above-mentioned introduction, metrology uses various strategies (methodologies) and various tools to uncover a hidden information coded in recorded outputs of systems [6–13]. Complex systems represents a class of systems where the scale of structural, parametric and functional entanglement is high, thus the quantitative concluding about the isolated properties and/or state of the system is difficult and needs original measurement procedures and devices.

From a technical point of view, the energy efficient smart building accumulates the knowledge and the experiences from various areas of science and technology, i.e. architecture, material sciences, civil engineering, environmental engineering, electrical sciences, control systems, telecommunication, information technology, medical sciences, etc. Most of these fields of knowledge apply to the concrete elements of technical infrastructure implemented in the energy efficient smart building and can be characterized individually. But the coexistence of these elements within the border of one big system inhabited by residents and embedding of such system into environmental reality constitutes the complex conditions which should be known and managed in objective way to achieve (widely comprehended) optimal conditions for life.

The paper provides the review on the issue of local and general measurement in the complex systems for example of the energy efficient smart building with implemented the functionality of telemedicine. Here, the local measurement is the act of measurement observation where the complex system is perceived as the set of subsystems constituting a recorded output. On the contrary, the complex system can be comprehended as a whole and the individual facts on such object are revealed then by global markers, e.g. proper for the complexity measurements [14–16], the fluctuation analysis [17], the complex networks [18,19], etc. These description outlines the range for fundamental research in chosen domain of modern measurement. What is more, the details on the smart building, its technical and measurement infrastructure, telemedicine, etc. were provided. Taking into account the specificity of the Polish society and market, the smart house with implemented the functionalities of telemedicine and ambient assisted living [20] shows a significant potential for innovation and commercialization of the research results.

2. Smart building

Depending on the practical destination of the building, i.e. family house, office building, plant building, it allocates spaces for families, individuals, workers, team(-s) working in an industrial conditions, etc., to stay inside while being safe, relaxed, facilitated and satisfied in their activities. It is the place where people carry out all their personal and professional interactions such as eating, playing, sleeping, entertaining guests, working, and many other functions. Thus, the building is comprised of functional spaces, which have a great potential for substantial influence on the quality of life, creativity and productivity.

Referring to the emerging information and communication technologies, the concept of smart is receiving a great attention worldwide. In particular, in the field of built environment, interdisciplinary studies highlight the fundamental role of smart houses and their significant impacts on the quality of user's life [21–23].

Initially, smart house was defined as modernized sensor-embedded residence with various integrated systems that are capable of communicating each other while being controlled remotely [24]. Thus, the concept of a smart house was basically focused on two constituents: it had to be fully integrated with ambient intelligence environments, and it had to base on the interrelations between the users and environments. But this concept has been directly associated with additional prerequisite – the issue of sustainability. The term of sustainability enforces the interdisciplinary attempt and incorporates the mutual enrichment of society, environment and economy. Sustainability conception brings the specialists working in a domain of smart building to the problems of ecological design principles, social attributes, environmental performances, lifecycle impacts, cultural responsiveness parameters, well-being criteria, and economic concerns. Since the time, context, size, social uncertainties, etc., can shape interpretations on intelligence embedded into the building, thus objectivation of intelligent performance needs the measurement uniqueness between three main components: people (householders, users), products (facilities, equipment, devices, sensors and physical features) and processes (interrelations, performances).

Beside the fundamental focus of designers and the same concept of smart house on the utilization of intelligent technologies, the development of intelligent building design is crucial as regards the accomplishment of the sustainability conditions. In fact, the control of energy performance while enhancing the quality of users' life is among the main goals.

3. Energy efficient building

The topic of energy efficient building has received increasing attention in recent years, until becoming part

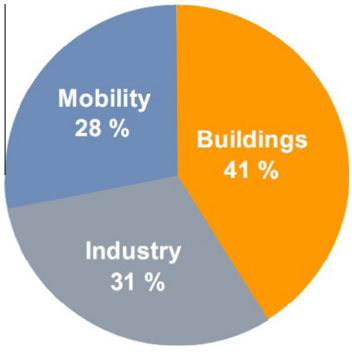

Fig. 1. General profile of energy consumption in Europe.

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