Project "Unified Modular System of Remote on-line Monitoring of Environmental Parameters of Depositories and Expositions"

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Abstract The paper outlines basic concept of the system for indoor climate monitoring of exhibitions and depositories of museums, which is currently developed in a four-year project. The project concentrates on design and deployment of system of sensors, the related infrastructure for communication between these sensors and the server for centralized data storage, access and processing. The components of the planned system are modular in order to meet specific requirements of various collections. The expected outcomes also envisage the development of specialized sensors e.g. for pest control and development of mobile version of sensor units for supervision of collection objects during transport.

1 Introduction

The National Museum of the Czech Republic is the largest state-owned museum in the country. It manages and curates large collections of much diversified nature. As objects in collections range from minerals to herbariums and taxidermied animals to precious works of art, any possible decay mechanism known to operate upon collections can be found there. Therefore extensive research and protection plan is fulfilled in dedicated laboratories of the institution to improve collection care and make it more effective.

The buildings of National museum also vary considerably. Buildings' period and style span over several centuries from medieval castles and chateaus to modern steel and glass buildings constructed at the end of twentieth century. Some structures were intentionally built keeping collection and museum functionality in mind, while others just happen to be converted into museum. In the second case, needs of collections are met with great difficulties or only partially as a trade-off. The reason is usually a conflict in needs of protection of building authentic historical value and requirements of items kept in collections [HKM+12], [LLR+08].

In order to prevail the above-mentioned drawbacks and to increase quality level of protection of collections, it is necessary to overcome absence or incompatibility of existing infrastructure of sensors and create a system capable of continuous monitoring of indoor environment.

2 General description of the system

The goal of the system is to enable central storage, unification and data mining of heterogeneous physical, chemical and biological data acquired by diverse measurement sensor devices. This goal is achieved by development of hardware platform alongside with a unified data structure. Unity of hardware and data components will be supported by a central processing of remote data in continuous way.
Therefore the requirement is that the system has to integrate various sensors in one platform, make data available for a long time and also in a format readable and easy to process in on-the-fly manner as well as ad hoc. Acquired data are partially processed locally and then also stored in unified format on dedicated server for consequent data-mining. Sensors, selected by requirements of collection and environment, are connected to the control module providing sensor interface and data acquisition and where possible, also all necessary pre-processing. The communication unit is chosen and connected to the control unit based on specific data transfer opportunities at given location: at some locations metallic connections are available, while elsewhere only wireless connection can be established (Figure 1).

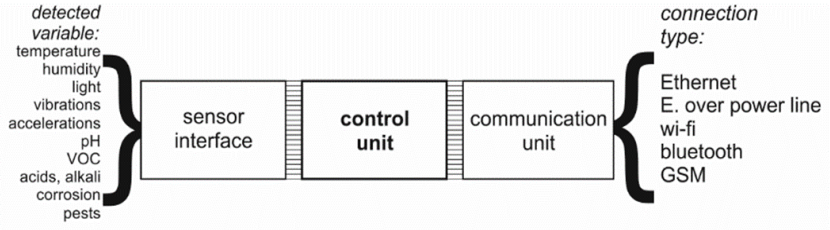

Figure 1. Schematics of communication and control connections between units showing scope of variables measured by sensors

The design of sensors also varies according to available power supply: sensors can be made very energy efficient and fulfilling their duty for as long as a year powered only by a pair of batteries. This is a necessary provision for situations when sensor is located on a remote and hardly accessible place, or has to be sealed in a display case with the exhibited object.
Another important aspect is that the modular system is built upon the concept of "internet of things" making possible for one device to interact with others – to use other's data, or to order the other device to do something without direct human involvement. Necessary prerequisite for a machine-to-machine data exchange is computer-readable data based on rich metadata enhanced semantic.
Depending on task complexity and resources available, also design of units may vary, from the simplest and single-purpose autonomous unit to the dedicated data server. Tasks are distributed among units via hierarchy of layers as depicted in Figure 2. The hierarchy also determines communication between units, e.g. level of data processing and interpretation based on unit computational power, communication bandwidth and energy-saving regime. The bottom two layers can operate for a prolonged time off-grid.

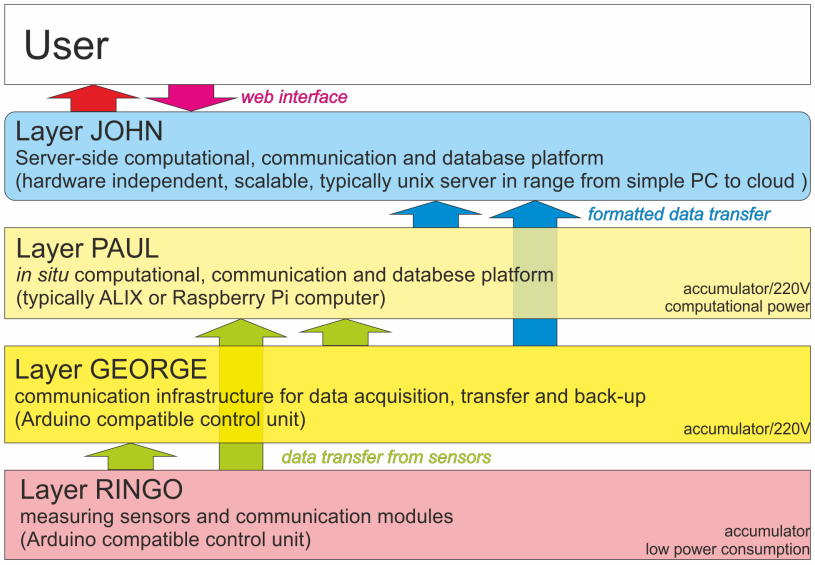

Figure 2. Schematics of layers and their dependencies in the system

3 Sensors

The general goal of the project is thus the improvement of cultural heritage objects protection against negative influences like unsuitable climatic parameters of environment e.g. temperature level and fluctuations, humidity level and the presence of volatile organic compounds (VOC) or by presence of biological pests [Dvo01]. Therefore the development of specialized sensors is a substantial part of the project. Development is carried out on variety of sensors, which can be classified according to measures variables: physical (temperature, humidity and light intensity), mechanical (vibrations, accelerations), chemical (pH, VOC, acidity and alkalinity, corrosivity) and biological sensors. Only mobile and pest detecting sensors would be briefly mentioned here (for a review of specialized sensors developed for museums' needs see e.g. [BCM+08]).

In addition to data from stationary exhibition room, data acquired during the transport of a collection are crucial for their protection. In this case it is recorded by a special set of mobile sensors capable of recording spectra of forces and vibrations directly threatening the objects, as well as other parameters like temperature, humidity and concentration of volatile compounds, which can be time to time released by 'protecting' transport box.

As pest infestation represents a serious threat to collected items, it is an important task to develop biosensors capable of indicating of pest presence and concentration. Therefore developing reliable means for pest detection is given considerable effort. Availability of communication networks as well as affordable electronic components make it possible to build specialized sensors for detection of pests and perform detailed automatized surveillance of vast areas otherwise impossible to guard by museum's personnel. Figure 3 shows a simple camera-based device enhanced with image analysis application counting increase of number of captured moths. As the flying insect sensor was located in a remote area, only a limited communication bandwidth was available and therefore it was a necessity to reduce the transmitted information to bare minimum. Therefore image analysis was applied to "interpret" view field and only a number of detected moths was sent to remote server.

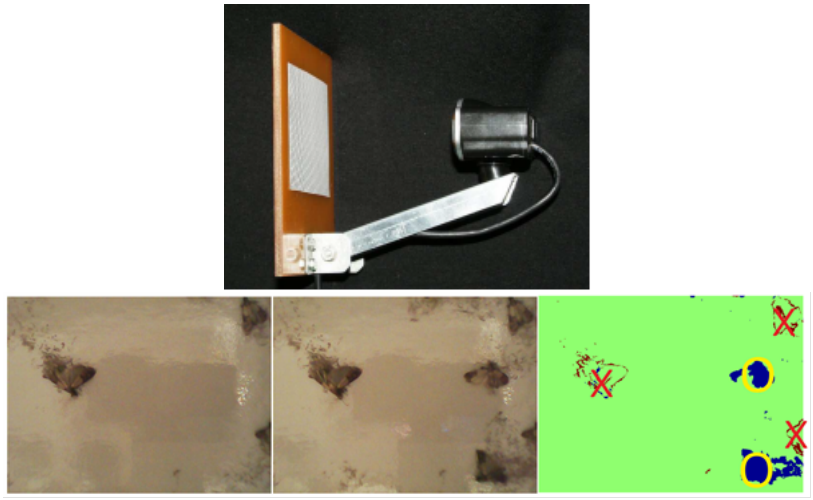

Figure 3. Detector of flying insects with an example of image data processing illustrating incremental counts of captured moths

4 Interaction with visitors

The project is focused mainly on monitoring museum's collections. This seemingly common task obtains a new dimension if it is not seen as mere problem of indoor environment regulation and control, but also as a source of valuable data, which may be of the interest not only to museum curators, restorers and conservators, but also to public attending exhibitions.

This way task of museum environment control and its importance for collected items protection can be made a part of visitors' experience. The data records elucidate many aspects of curating collection, but also pose a strong supporting argument in favour of attempts to further develop virtual museums concept. Data like this can raise visitors' awareness on the problems related to protection of priceless objects stored and shown in museums and also pave the road for deeper understanding of transitions towards virtual objects as not only enhancing and extending experience, but also a necessary step in protecting our heritage for generations to come.

Our sensors placed next to shown objects can directly transmit and process measured data and display it on-line on the screens located in the same exhibition room. Information on indoor environment presented in real time in accessible form remind visitors on delicate nature of the items and possible induced decay or weathering, (see Figure 4). Sensitivity of the measurement is sufficient for demonstration of feedback between time-dependent flux of visitors and sudden changes in parameters like temperature, humidity and light intensity. There is a positive response from visitors of exhibition intrigued by the possibility to observe such a data.

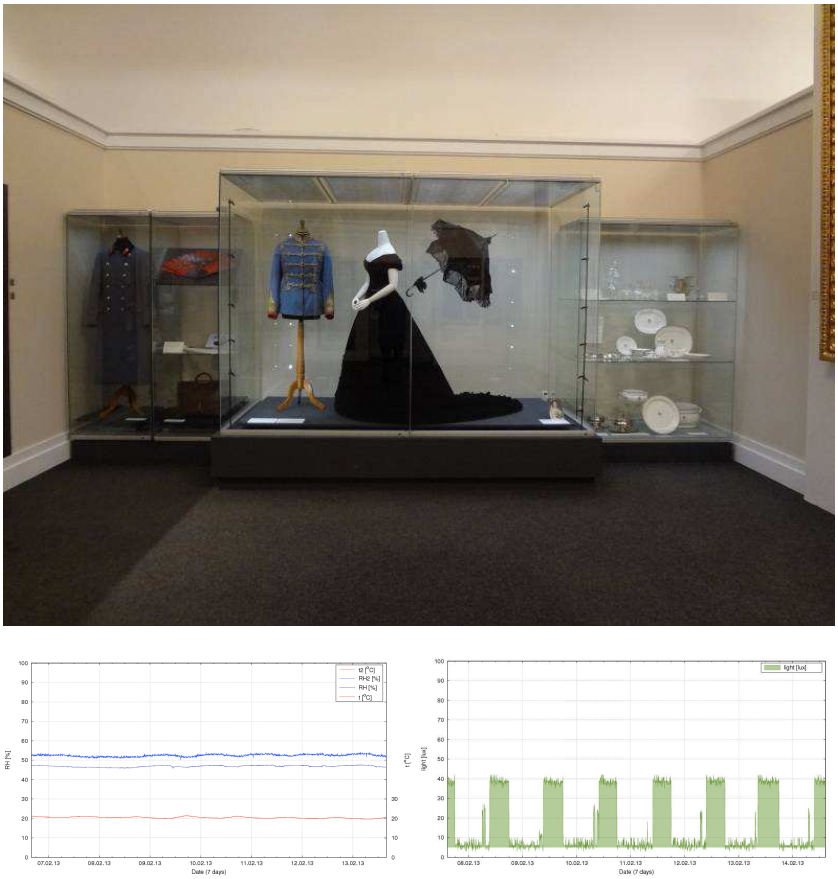

Figure 4. Display of emperor's uniform and empress Sisi dress in the Monarchy exhibition –upper part of the figure. Temperature, humidity and light intensity plots presented to visitors of exhibition

5 Conclusions

The National Museum of the Czech Republic is responsible for many collections of very diverse nature, which implies that also threats of the protected item differ significantly. The modularity of sensors is thus of great advantage. Continuous evaluation of environmental parameters of depositories and collections situated in the various types of objects represents a qualitative improvement of collections' protection, based on a possibility of a warning system automation of abnormal state situation in a given location. This way it is possible to eliminate or reduce severity of damages and losses in irreplaceable historical collections by shortening of the response time.
More detailed description of the project can be found in [SVJ12].

Acknowledgement

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