Geographical information systems and monitoring of climatic conditions in cities

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Abstract. Modern geographic information systems are able to visualize almost any information in their maps. Important is the data that the GIS should visualize. This data consists of information from the cadaster, passports or city plan. This paper discusses the possibilities of visualizing climate data based on a sensory network. The results can be used in the planning and development of the city. Internet of Things is a modern part of the Smart City concept that forms the basis of the modern city. The world's most modern cities are equipped with hundreds or thousands of sensors. The data can be used for planning and development of the city. The result is more efficient facility management of the city, administration and operation, strategy and planning. In conjunction with building information management, more precisely city information management, significant savings can be achieved. Climatic conditions measure various institutes outside the influence of the city. For efficient use of data, the possibility to operate these sensors operatively and deploy them according to their own requirements and needs, the city should have its own sensor network for measuring climatic conditions.

1. Introduction

At present, geographic information systems (GIS) have undoubted use not only in the environment of municipalities. This is an essential part of property management. But they are also used by companies that manage areas or have a wide portfolio of buildings. Smart cities take advantage of other GIS functionality, such as IoT and the sensory network. In the case of cities, smart cities, it is the deployment of various sensors in urban areas or inside buildings and monitoring real-time information. There are many measurable values. From air quality, climatic conditions to noise, traffic or parking. Internet of Things is a modern part of the Smart City concept. It is a system of interconnection of various devices that are able to exchange and share data with each other. It is a sensory network connected to the Internet and databases that can measure various quantities, evaluate them and report. They allow, for example, to minimize security risks, reduce costs, and increase living standards. It is an ecosystem that uses digital and communication technologies to improve the quality of life in homes and entire cities.

Building Information Modeling / Management (BIM) is closely related to the Internet of Things and effective facility management in cities. It links several areas into an effective ecosystem of a single information database. In the case of cities, we can talk about city information management (CIM). City information management connects BIM and GIS or we can say GeoBIM.

Climatic conditions are currently being monitored; this is not a novelty. However, they are not connected in real time with GIS systems and city administration. This combination could bring many benefits and make the city administration more efficient, but also bring benefits for long-term planning and strategy. If the information about climatic conditions could be visible and visualized directly in the map with
other information and maps, e.g. cadastral map, flood map, land-use plan, etc. much more efficiency can be achieved for individual workers. This is determined by the awareness of users. Connecting relevant information without the need for lengthy searches can be key to reducing costs, security risks or crisis situations of city.

2. Geographic information system
As such, GIS technology originated in the late 1970s through the introduction of computers and computer graphics into the work of architects, environmentalists and land-use planners. In connection with tools of relational databases and with the overall development of automation of engineering works, both the intensity of utilization of these computer activities and the further development of more and more specialized tools gradually increased. At present, they are not only an independent computer science branch, but also a number of its specialized sub-disciplines, both in theoretical foundations, in hardware provision and software equipment [4]. Figure 1 shows a conceptual model that shows us very simply the use of GIS.

![Figure 1. GIS conceptual model [6, author].](image)

IS is deployed at every stage of planning and development of a Smart City. The underlying framework is served by ICT (Information and Communications Technologies), while the focus is on the ‘spatial’ or GIS. The common platform operates through all stages of the life cycle – from modeling, planning, building to managing – across the full spectrum of functionalities [5].

3. BIM, GIS and Smart City is CIM (City Information Management)
City Information Modeling generally involves building a 3D city model that connects with BIM and other contextual data source or analysis tool of various city components, including buildings, roads and public spaces (open data), IoT and other smart city elements.

However, BIM is at the core of the smart city, in that it fosters improvements in energy and cost-efficient buildings, facilitating more sustainable urban development, and is key to tackling many of the challenges mentioned above. CIM (city information modelling), a relatively new adaptation of BIM technologies, goes one step further than BIM, integrating the information provided by BIM into wider city planning and development. The economic, social and environmental benefits of integrating BIM at different spatial scales within the city [7].
CIM is definitely useful for architects and planners in individual building, campus, and town planning projects of any scale. By connecting BIM to CIM, users are provided with an interactive, content-rich 3D city model environment, where data can be accessed, analyzed and shared anywhere in the world, in real time. It is also useful for facility management, which uses both 3D models and the data contained therein. The 3D model of the city can also be used for simulations. [1]

4. Internet of Things and sensors

The Internet of Things is a new trend in the control and communication of everyday objects with one another or with one another, in particular through wireless data transmission technologies and the Internet [2]. By implementing IoT, there is a wide range from a bulb that will change its luminous intensity depending on the intensity of the ambient light, to, for example, a washing machine sending information about the wash cycle status to a mobile phone application. Communication in IoT usually takes place at the machine-to-machine or human level. This communication is mostly wireless. Many technologies are used to communicate with the device, such as: RFID, Bluetooth (low energy variant), Zigbee, low power WAN and many others. The choice of communication technologies depends on the way of use, economy, environment in which the technology will be used and other preferences [6].

4.1. Possibilities of IoT and visualization into GIS maps

- Air quality
- Precipitation measurement
- Other climatic conditions

4.2. Other measurement possibilities of IoT

- Parking
- Traffic intensity
- Noise measurement
- Movement of persons
- and more
5. Data from available sources
Other sources may be, for example, information from the Land Register or other online databases. These databases usually allow direct connection to online GIS and information retrieval. In the case of climatic conditions in the Czech Republic it can be e.g. database of the Czech Hydrometeorological Institute.
Sensors can measure at different intervals. The intervals can be preset automatically or the user can set and monitor the data on the map according to his own needs. From real time to measurement to once a day or weekly. It depends on the measured elements and for what we use the resulting information.

6. Visualization and solutions
Visualizing data with interactive maps helps find new information and the interconnectedness of this information. Map content may be supplemented by pop-ups, which may include graphs, photographs and links to websites or other detailed information. Internet access guarantees the use of information and maps from anywhere and for any user. Such maps are quickly and easily accessible. Another visualization option is through smartphones or tablets. Free downloadable applications for smartphones and tablets allow you to access maps anytime, anywhere. Data can also be collected and analyzed or changed using a mobile device. It is possible to enter various information into the maps using the user's smartphone location and location.

7. Benefits and possibilities for the city
There can be many uses of the information obtained from the IoT sensory network. From analysis, simulation and evaluation e.g. overheating of housing estates, use of rainwater, prediction and prevention of flood and flood areas, through the spread of urban pollution, dustiness, to long-term strategies and planning of city development.

- Simulations using 3D CIM model
- Long-term analysis for the Planning and strategy (city development)
- More efficient operation and maintenance (facility management)
7.1. Positioning tables
Simulations using current climatic data can be used for different purposes. This can be from local sources or from external sources outside the city (factories, etc.). Knowledge of current wind movement by the built-up area can be of great benefit.
A very discussed topic is overheating of housing estates and built-up areas. Actual temperatures recorded by sensors installed effectively in the built-in area can help to plan solutions and remedies. On the basis of these values, concrete cities can plan the greenery and adapt the space with architectural designs.
Rainwater can also be measured using sensors to get truly relevant information from places of interest to us. Large concrete areas and roads where spontaneous absorption does not occur. In these places it is possible to efficiently use rainwater and accumulate it in reservoirs. Recovery can come in the dry season. In other river basin districts, flood predictions may occur due to precipitation.

7.2. Long-term Analysis for Planning and Strategy (City Development)
Long-term analysis of climatic conditions can contribute to planning and strategy - city development and for more efficient operation and maintenance. The output can be an effective planning of the development of the city e.g. through territorial and regulatory plans.

7.3. More efficient operation and maintenance (facility management)
Facility management is an effective tool for asset operations and maintenance. Cities have many buildings, roads, greenery, furnishings and other facilities that need to be effectively maintained and operated. The sensory network can help to report problems and draw attention to impending crisis situations. Information on current conditions and assets under management and subsequent prediction of problems is a key factor in facility management that can save high costs. [3]

8. Conclusion
IoT is modern, innovative and has many benefits for the end user. There are many elements that can be measured. However, it always depends on correct data interconnection and synergy. How we can interconnect data and use it effectively to analyze it together can save work, time and money. CIM is a modern city view concept using innovative BIM, Smart City concepts and modern GIS tools. Sharing these areas together can guarantee efficiency gains in the area of city management, development and long-term strategy. It can also benefit all city citizens.
The problem of already deployed third-party sensors that normally operate and are deployed in cities is that they are fixed in certain locations, but not according to the needs of the city. There are a very limited number, usually one piece per city, in larger cities are in the order of a few pieces. However, if we want to effectively use information from IoT and the sensor network, a much denser network of these sensors is needed to make the data relevant and usable.
Proper placement of own sensory network and connection to own GIS system is the future of city management. If it can be combined with a 3D city model and data, we will create a modern smart city - a digital twin in a virtual environment accessible from anywhere. The virtual world is all around us and we use it for everyday activities. It is an integral part of cities, citizens and companies. A common interconnected ecosystem can bring benefits to all. Climate change and climate extremes are a topical issue. Cities must respond to these conditions if they are to be smart and efficient, ensuring maximum comfort for their citizens. However, this is not possible without relevant and up-to-date data.

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