ДЕРЕВЬЯ КАК ПОКАЗАТЕЛИ СОСТОЯНИЯ ГОРОДСКОЙ СРЕДЫ

Попкова Е. В.

РУДН

e-mail: pvv.elena@gmail.com

АННОТАЦИЯ

Статья посвящена изучению состояния городской среды и разработке сайта для мониторинга этого состояния. В статье обосновывается актуальность проекта Smart Urban Nature, дается описание устройства, используемого для сбора необходимых данных, и описание разработки сайта. В качестве территории для исследования были выбраны город Москва и прилегающие территории.

Ключевые слова: *урбанизация, окружающая среда, зеленые насаждения, деревья, устройства, данные, сайт*

TREES AS INDICATORS OF THE URBAN ENVIRONMENT STATE

ABSTRACT

The article is devoted to the study of the urban environment state and the development of the site for monitoring this state. The article sets out the rationale for the relevance of a Smart Urban Nature project, a description of the device used to collect the necessary data, and a description of the site development. The Moscow city and the surrounding territories have been chosen as a territory for the study.

Keywords: *urbanization, environment, green spaces, trees, devices, data, site*

Nowadays economic and environmental problems such as population growth, urbanization and climate change have a great impact on our live. According to the United Nations (UN) forecasts (medium fertility variant), the human population will reach an estimated 8.6 billion in 2030, 9.7 billion in 2050 and 10.8 billion by 2100, while now - in 2020 - there are already 7.8 billion people [UN, 2019]. Speaking about urbanization, even now, the urban population accounts for 56% of the total population, and by 2050, according to forecasts, it will make up 68.4% [UN, 2018]. All these facts demonstrate the significance of the state of urban ecosystem on modern human life.

Since the majority of people live in cities, it is important for the urban environment to be in good state, but unfortunately it is not so. In the urban environment there is a huge release of toxic substances, which causes irreparable harm to ecosystems. The constantly growing amount of harmful substances emission causes various diseases and leads to the deterioration of human health. Therefore, it is very important to use urban resources rationally and to approach the organization of green spaces in cities with special care. Soils and green spaces do such important things as carbon sequestration, microclimate formation, pollution and dust reduction in the atmospheric air, water balance control, and also bring aesthetics to the city's infrastructure. So a detailed analysis of the ecosystem services, as well as the assessment of potential environmental risks are necessary for the modern city development.

Despite the fact that the importance of the urban environment is well-known, there are no readily available technologies for monitoring and assessing the state of soil and green spaces. Because of the high dynamics and heterogeneity of urban soils and green spaces state, it is necessary to introduce completely new intelligent technologies that are capable of rapid monitoring and assessment of the urban environment state. Based on this need, a Smart Urban Nature project (SUN project) has been created, the tasks of which are as follows:

1) the development of smart technologies (express sensors, the Internet of things, big data analysis, machine learning) for monitoring and assessing dynamics, functions and services of urban soils and green spaces based on their spatial heterogeneity, temporal dynamics and anthropogenic load;

2) modeling the influence of urban mesoclimate on the urban green infrastructure state and forecasting changes in urban ecosystem.

The main study area is the Moscow megalopolis, one of the largest urbanization centers in Europe. Of particular interest for study is the New Moscow, a new territory adjacent to the old city in 2012, as an area where intensive urbanization is taking place. The developed technologies will subsequently be used in other cities and will provide information on the ecological state of the urban environment, which is

extremely important for decision-making in the field of urban governance and sustainable development of the urbanization process. One of these developed technologies is TreeTalker.

TreeTalkers

TreeTalker is a device which is able to monitor the following parameters: water transport inside the plant, the diameter growth, the quantity and quality of foliage (light transmission in four spectral bands), climate and soil parameters (temperature, humidity), the tree stability using a gyroscopic sensor, the air temperature and humidity, the soil temperature and humidity. There are several versions of TreeTalkers: TT+ (using thermal dissipation for sap flow), TT++ (using heat pulse velocity), TT-CARBON (for specific carbon sequestration studies) and TT-FIRE (for fire prevention and detection). The TT+ version will be described here, which uses a heat dissipation sensor to measure a juice flow (Granier method).

For the TT+ version a method proposed by A. Granier [Granier, 1987] is used to collect mentioned data, the scientist inserted a needle with an electric heater into the sapwood of a barrel and measured the difference between the temperature of the heated needle and the sapwood at some distance below the needle. This method is called the Thermal Dissipation Probe (TDP) method. The sensor measures the heat transfer of the sapwood, which increases with the sap flow and cool the heat source. When the sap flow rate is zero or minimal, the temperature difference (ΔT) between the two sensors is maximal. When the flow increases, this temperature difference decreases [Dynamax, Inc., 1997].

There is the schematic of the TreeTalker device:

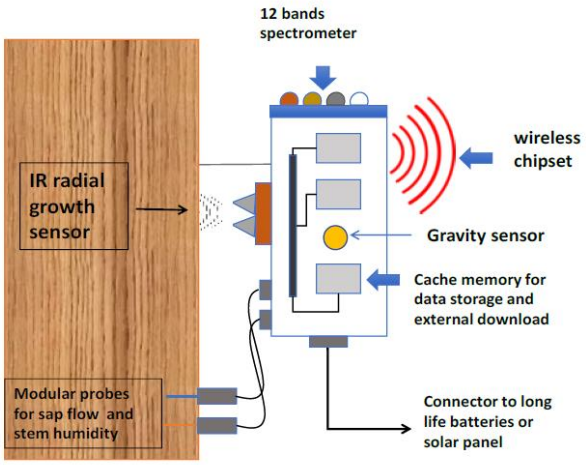

Figure 1. The schematic of the TreeTalker device

The new TreeTalker device version "TT+" collects the following parameters:

Tree radial growth, as an indicator of photosynthetic carbon allocation in biomass;

Sap flow, as an indicator of the tree transpiration and functionality of xylem transport;

Xylem moisture content as an indicator of hydraulic functionality;

Light penetration in the canopy in terms of fractional absorbed radiation;

Light spectral components related to the foliage dieback and physiology;

Tree stability parameters to allow real time forecast of potential tree fallings.

Additional parameters such as air temperature and humidity also will be collected [Nature 4.0 SB Srl].

Data from each TreeTalker in the form of two strings is sent to the data server. The first string is type 45 string has the following parameters: Server Date, Server Time, TT ID, record number, device type, Timestamp, Tref_0 [*10, °C], Theat_0 [*10, °C], growth sensor [d.n], Battery voltage [d.n.], number of bits, Air relative humidity [%], Air temperature [10*° C], g_z(mean) [d.n.], g_z(std.dev) [d.n.], g_y(mean) [d.n.], g_y(std.dev) [d.n.], g_x(mean) [d.n.], g_x(std.dev)

[d.n.], Tref_1 [10*° C], Theat_1 [10*°C], xylem moisture content [freq (Hz)]. The second string is type 49 string has spectral data: Server Date, Server Time, TT ID, record number, device type, Timestamp, AS7263_610 [d.n.], AS7263_680 [d.n.], AS7263_730 [d.n.], AS7263_760 [d.n.], AS7263_810 [d.n.], AS7263_860 [d.n.], AS7262_450 [d.n.], AS7262_500 [d.n.], AS7262_550 [d.n.], AS7262_570 [d.n.], AS7262_600 [d.n.], AS7262_650 [d.n.], integration time, gain. According to Treetalker ID (TT ID) and record number, we can combine these strings to get a holistic view of the data for further processing.

Visualization

Ultimately, we will have an information system, entering it everyone can see statistics for each tree. As an information system, it was decided to develop a website, the further development of which can already be observed on the website [Smart Urban Nature].

Speaking about the website design, all pages of the site have a common structure: the left side is the menu (light green, RGB - R: 50 G: 20 B: 58), the right side is the page of the selected menu section (white).

The menu has a white logo under which the menu sections “Places” and “Contact” are located.

At the moment, the site in the “Places” section has a map of the studied places in the Moscow region: the RUDN University Campus, Forest Research RGAU, Botanical Garden, School No. 1234, Bolotnaya Square, Cherbinka, Troitsk. We can zoom the map in and out to the area of our interest. When you click on the place, a window containing general information on the place: name, address, number of TreeTalkers and the ability to go to the place map using the “More” button will pop up. When we get to the place map, we can see many TreeTalkers, if you click on the one of them, a window containing The tree condition, Species, Battery voltage, DBH pops up. When you click the "More" button in the described window, you will get to the device page containing more detailed information. Below is the element for selecting the characteristics in question, it lets you build the following graphs: Water Uptake [L/h], Diameter growth [mm], Vegetation index,

Photochemical reflectance index, Average angle of stability, Air temperature [°C], Air humidity [%], Wood moisture [%], Tree temperature [°C] and Battery voltage [volts]. Choosing a parameter, we can see a graph demonstrating changes of this parameter over a certain period of time (to the left of the graph are quantitative indicators, below is a time scale). By default, the voltage option is selected. Below this characteristic is a graph of the tree parameter of interest, which can be zoomed in and out, and also moved using the mouse or touchpad.

System Architecture Description

The system consists of the following elements:

- backend;
- API layer: implements the functionality of receiving data from SUN Project sites, transferring data to the backend, as well as transferring data from the backend to the user's web application, which is a Java Spring Boot application;
- web user application: implements the functionality of the graphical interface, it is an Angular application.

The parts of the system work in their own Docker containers, the settings of which are contained in the corresponding Dockerfiles.

Backend application

The application using the Spring boot framework is aimed at:

- Data storage (Postgre DBMS is used for data storage);
- Data processing, business logic of the application;
- Subsequently, data analytics.

Layer API application

The application using the Spring boot framework is aimed at:

- Receiving, carrying out data pre-processing and sending data from the sites aggregating data from the TreeTalker sensors to the backend layer;
- Receiving data for the user interface from the backend layer and exchange with the Frontend application.

Frontend application

The web application is developed using Angular 7 framework and works using Node JS version 10 and higher.

The application consists of the following components: contact (responsible for the page with contacts), dashboard (responsible for the main page, at the moment it contains just text), not-found, places-map, ttcard, ttcard-basic-info, ttcard-data-vis, ttmap.

The application implements services PlaceService (used to obtain data on the locations of TreeTalker sensors), TreeTalkerService (used to obtain data on sensors), TreeTalkerDataService (used to get statistics data from sensors).

The main libraries that the application uses: Angular Material (used to render some interface element, RxJs (used to implement a reactive data exchange paradigm), HttpClient (used to receive data from sources), Bootstrap (used for layout of application templates, including adaptive), Router (used to implement navigation in the application), Chart.js (used to plot charts), Angular Google Maps (used for working with maps).

Conclusion

Ultimately, having developed the site, we will be able to observe the urban environment state by analyzing and processing the data collected from the trees by TreeTalkers devices. We will also be able to trace changes in the parameters of the tree, by which it will be possible to draw conclusions and, on the basis of these conclusions, make decisions on the improvement of the city.

At present, a SUN project is under development. The receipt of the final product in the form of a website is scheduled for July 2020.

References:

[1] Dynamax, Inc // TDP Thermal Dissipation Probe User Manual, 1997. URL: http://dynamax.com/images/uploads/papers/TDP_Manual.pdf (access date: 11.01.2020).

[2] Granier A. Evaluation of transpiration in a Douglas-fir stand by means of sap flow measurements. // Tree Physiology. 1987. 3 (4). P. 309-320.

[3] Nature 4.0 SB Srl // The TreeTalker Technology. URL: https://www.nature4.org/technology (access date: 11.01.2020).

[4] Smart Urban Nature. URL: http://sun.amct.institute/ (access date: 11.01.2020).

[5] United Nations // World Population Prospects 2019. URL: https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2019_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.xlsx (access date: 11.01.2020).

[6] United Nations // World Urbanization Prospects: The 2018 Revision. URL: https://population.un.org/wup/Download/Files/WUP2018-F02-Proportion_Urban.xls (access date: 11.01.2020).