Using a web application to realize the effect of AR in assessing the environmental impact of emissions source

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Abstract. Revolutionary technologies of nowadays are virtual and augmented reality. Humanity's concern for nature may be affected by their ability to combine reality with the simulated effects of human impact on the environment. An urgent task today is creating software applications to assess the impact of human activities on the environment. Recently, most scientists have been trying to model the impact of various factors on environmental change today and for decades using information technology. Visual models are very impressive and they also make a deep impression on the psychological state of the person. This forces people to use natural resources wisely. In this article we have considered the sequential process of building and implementing models for assessing the impact of pollutants from a stationary emission source. We have created a software product that helps to show visually how the emissions of a chemical plant are spreading to the surrounding city. The harmfulness to the city of the cloud into which emissions are converted can also be calculated by the program. We have implemented a number of functions responsible for emission modeling, taking into account different conditions.

Keywords: web application, pollution, emissions.

1 Introduction

In the era of revolutionary technologies of VR and AR, students have many opportunities for development and learning [17; 24].

In the context of the COVID-19 pandemic, education around the world is making a leap and urgently moving away from traditional learning. Every day more and more applications are created to work in virtual classrooms, to perform virtual laboratory work and conduct experiments [11; 3].

These teaching methods can become a major tool in education and revolutionize learning [12; 7]. Teachers can use VR and AR to interact with different objects in three-dimensional space.

Augmented reality through the educational environment can eventually be crucial to the future of our planet.

Computer visualization is a powerful tool for demonstrating to mankind the crisis state of the planet. The ability to master modern methods and tools of computer visualization allows you to present information in forms that enhance perception, greatly simplifying and accelerating its analysis, synthesis, evaluation and forecasting, which makes these skills an integral tool of modern scientific research and practical activities in the field of nature management and environmental protection.

In the modern world, environmental problems in their social significance have come to one of the first places. The rapid development of human activities led to an intense, often destructive, environmental impact. Human influence on nature occurs both through the transformation of natural systems that have developed over millennia and as a result of pollution of soils [6], water [9], and air [19], [4]. This led to a sharp deterioration in the state of nature, often with irreversible consequences [20]. The environmental crisis is a real danger: in almost every region we are witnessing the rapid development of crisis situations [2].

The development of information technology in particular information tools (services) makes it clear the need to increase the intellectualization of tools for visualization of research results in environment as well as the creation of software that meets the requirements of modern IT which could be easily modified and adapted to constantly changing research conditions [18]. The emergence of a new approach to the visualization of result information can bring systematic environment research to a new level of information perception [8], [23].

The main reason of the work was to develop a mobile application that allows you to minimize the calculation of the range of pollution spread from emission sources and visually understand the algorithm of this dependence

The use of virtual and augmented reality for environmental awareness is not the first tool. But it is difficult to ignore its potential to reach a new audience and effectively educate its impact on pollution.

2 Literature review

Modern visualization technologies using VR and AR are very fully described in works [1; 10; 15].

Augmented and virtual realities are just beginning to be used in environmental education. Here are some examples.

“Every Kid in a Park” is an initiative led by the USDA Forest Service. This application allows you to learn about natural resources, culture and history of the country [25].

“Agents of Discovery” – this game has 50 forests of America. Playing it, you can learn a lot of interesting things about the environment and master the possibilities of augmented reality. This game gives you the opportunity at an early age to start taking care of the environment, forests, their flora and fauna [25].

There is another application that allows you to immerse yourself in the world of the underwater kingdom – Our Ocean Life. This is an exhibit at the Art Science Museum

in Singapore, which visually illuminates the huge amount of plastic that people dump [25].

Consider which popular software projects for environmental protection [14; 21] and ecology exist, and can be reformatted and supplemented by augmented reality.

Commute Greener – Offers is the most efficient route on the map, as well as travel sharing in your area [16]. Lea fully – this application warns you when your power consumption goes overboard and requires a reduction. Climate Counts – it is a database which contains most of the world's largest companies, where they are ranked according to their work on climate change [16]. Green Meter is an energy consumption tracker for your car that is designed to identify and change your driving habits in order to save fuel. Pollution is an application for measuring air quality. It also identifies potential sources of pollutants in the air, water, and soil, from plants to power plants. Green Travel Choice is an application that tries to minimize the environmental impact of your trips. Climate Wikience is a free application for fast 3D visualization and analysis of environmental data [16].

3 Research methodology

The distribution of pollutants in the atmosphere around the source of emissions occurs in general according to the laws of the material world, which are mostly known to science in its various fields (Physics, Chemistry, Climatology, Theory of Random Processes, etc.).

The conditions that affect this process can be conditionally divided into the following groups (factors of influence):

- source parameters;
- flare parameters (dust and air mixture);
- Conditions of exit of the torch from the source opening;
- Characteristics of the atmospheric air in the emission zone (external environment) and characteristics of the underlying ground surface.

Consider the simplest model for calculating the range of atmospheric contaminants for a point-in-station discharge facility (enterprise pipe).To do this, we consider 4 consecutive stages of its implementation [21; 23].

The simplest model for the propagation of an individual air pollutant into the air is to take into account the influence of the height (H) of the source (i.e. a separate pipe) on the range (L) of the air pollution by this impurity. As a rule, this estimate will be rather approximate, but it is used for relatively rough assumptions in the first approximation.

Stage I. The range of propagation of a substance from the source of its release into the atmosphere, depending on its height (H) can be estimated by the expression

$$L(H) = K_n \cdot H, \tag{1}$$

where H – is a pipe height, m;

K_n – is a coefficient taking into account the aggregate state of the substance (for gases K^g_n=120, for solids K^s_n=90).

As a rule, the effect of the aggregate state is taken into account fairly approximately according to empirical evidence. However, at this stage it is possible to estimate the range of the contamination zone with a fairly satisfactory approximation. Nevertheless, this model allows us to investigate the effect of the height of the emission source on the spread of pollution in the ground layer of the air under unknown other conditions.

As a result of the first stage, we can conclude that by changing the height of the source of emissions into the atmosphere, it is possible to regulate in some limits both the magnitude of the concentration of the substance and the range of its distribution, and therefore the size of the contamination zone.

Stage II. Substances by aggregate state can be attributed to one of the following types: solid, gaseous, liquid and the like. Each of them is characterized by a different rate of sedimentation in the air. This directly affects the residence time of the pollutant in the atmosphere from the moment it is released into the atmosphere until it is deposited on the Earth's surface (or water surface).

It is known that the longer the impurities are in the air, the further they can be attributed to the source of its emission. That is, those over a larger area, different objects will be adversely affected by the polluted atmosphere.

Taking into account the settling velocity of substances of different aggregate state, it is possible to specify the model of the range of impurity propagation in the air. In this embodiment, the model looks like

$$L(H, F) = 30 \cdot (5 - F) \cdot H, \tag{2}$$

where F – is a rate of sedimentation rate of a substance in the air.

It is clear that the heavier the particles of matter, the greater the rate of their deposition, the closer to the source of their emission they fall to the surface of the earth (table 1).

Table 1. Values of the sedimentation rate of some substances in the air F.

Substances	F
Gaseous, aerosols, fine solids with a particle radius $r \leq 0{,}1$ μm (which are the germ of fog droplets and clouds)	1
Aerosols and fine solids at $r \leq 0.1 - 0.5$ μm (with a more than 90% emission purification rate)	2
Extremely solid at $r \geq 1$ μm (less than 75% or in the absence of purification)	3

Stage III. There is a physical pattern that more heated objects (gases, objects, layers of air) rise upwards (at least until their temperatures equalize) with respect to the less heated environment. The force of this direction is greater, the greater the difference between the temperatures of the environment and this object.

In relation to the dust-air mixture emitted by the sources into the atmosphere, this difference is called the torch overheating and is measured by

$$\Delta T = T_f - T_a, \tag{3}$$

where T_f – is the temperature of the torch of the dust-air mixture at the mouth of the source of its emission into the atmosphere;

T_a – is the ambient air temperature.

The magnitude of the lifting force determines the lifting height of the emission torch until the difference between the temperatures of the mixture of emission and ambient air disappears, i.e. $\Delta T \to 0$. This is a visual explanation of the behavior of the smoke pipes from the pipes of the facilities.

Taking into account the influence of temperature characteristics on the range of contamination, the model gives this expression

$$L(H, F, T) = 30 \cdot H \cdot (5–F) \cdot (1+ \Delta T / 75). \quad (4)$$

Stage IV. Not only air temperature, but also the direction and strength of the wind affects the nature and range of pollutants in the atmosphere. As the wind blows in different directions, as a rule, at different times, with different force throughout the year, impurities from the source spread at different distances in different directions.

The pattern of recurrence of wind directions during a year in certain directions is called the wind rose. We have spread eight octagon, which characterizes 8 directions: north (Mon), northeast (PNS), east (C), southeast (PdS), south (Pd), southwest (PZZ), west (C), north the West (Mon).The average frequency (P) of wind in a particular direction (% or fraction of a unit) is determined according to hydro meteorological statistics and can be used for different periods of time (average annual, season, summer, winter, day, etc.) for different terrain.

Taking into account the wind rose, the model of the range of pollution spread in the emission zone into the atmosphere of a point stationary source is refined.

$$L(H,F,T,P) = 30 \cdot H \cdot (5–F) \cdot (1+\Delta T / 75) \cdot P_i / P_c, \quad (5)$$

where P_i – is the recurrence of wind in the i-th direction;

P_c – is the recurrence of wind in circular wind corners (12.5%).

In recent years, web applications are developing rapidly, gradually replacing desktop solutions and becoming the most important component of the program development in the modern world [5].

A web application is traditionally divided into two parts: client and server [22]. The client part, or just the client, is the “face” of the application, what the user sees. It is responsible for the interface and direct interaction with users. The client prepares responses to it and processes responses from it. It’s providing to make a fast and universal application, which can be used from different devices [13]. That is why, that was chosen for the further development of program, which visualize clouds form changing and emissions from its according to special model of the spread of pollution in the emission zone.

In general, modeling of clouds form changing and emissions from it according to special model of the spread of pollution in the emission zone is divided into the next major steps: Validate Input, Get Wind Side, Calculate Model, Create Cloud, Show Result. Processing of texture objects involves the following: analysis of objects and the

selection of appropriate textures, materials or their creation, and then their placement in a scene for each object.

The main method for modeling 3D objects is modeling based on standard sets of devices, which, as a rule, serve as folding objects for folding objects. The process of visualizing objects, as a rule, consists of the following steps: preparing scenes for visualization and setting the appropriate settings.

Nowadays, when the computing power of computers has become quite high, the visualization of various natural phenomena is considered quite demanded by the task, since objects, connected with our environment as the sky or clouds are an integral part of almost any natural scene. All these details have a significant impact on realism and their implementation finds itself in various fields (development of computer games, special effects modeling, and animation creation). In a special way in this series modeling of the sky and clouds is highlighted.

Clouds are dynamic objects whose structure is complex and heterogeneous: their particles are uneven, both on the border and inside the clouds. They are constantly changing and often depend on additional factors. But when rendering attention is paid to particles on the surface of the clouds, as for effects associated with cloudiness, then one of the possible solutions to this problem can be considered the use of particle systems. This method is applied if necessary visualize a large number of small objects that do not have clear boundaries. And its principle is that all parts of the system have a similar appearance, a certain lifetime, and obey the same law of resizing, colors, speeds, etc. This method is often used in modeling such effects like a smoke, fog, and explosion. In our case, this is a suitable way for precipitation modeling.

The first preparation step is checking the side of the wind, which we will use in the future to visualize our system (fig. 1).

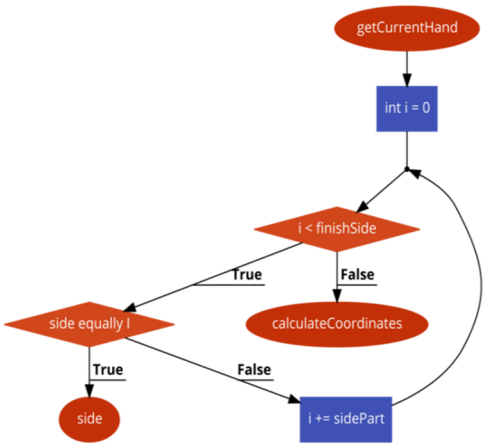

Fig. 1. Checking the side of the wind.

To calculate the distribution distance of clouds form changing and emissions, we use the following model (fig. 2).

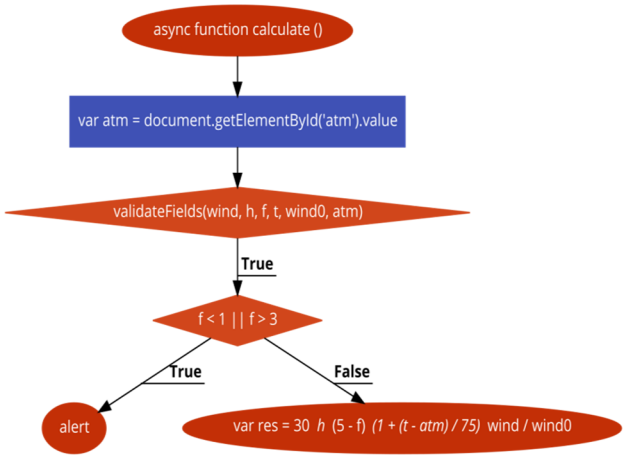

Fig. 2. The distribution distance of clouds.

After calculating we need to prepare some data, which need for visualizing. You can adjust the orientation of the polygon as follows. The vector product of the direction vector of the gaze and any other vector is no collinear with the first. The resulting vector lies in the desired plane. Turning it the right number of times, we get the tops of the panel responsible for the given particle (fig. 3) and (fig. 4).

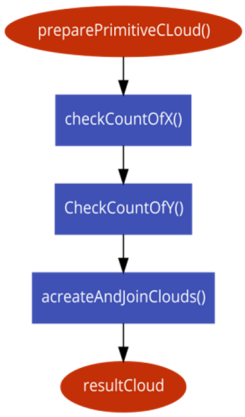

Fig. 3. Visualize cloud.

When implemented, the most important issue is the choice of the number of particles simultaneously present in the scene and the way they are renderings. For cloud's modeling, we use small circle of elements. This allows you to achieve a good visual effect. It is also worth noting that when turning the scene, the particles representing regular polygons can degenerate into segments, so the use of panels (fig. 5).

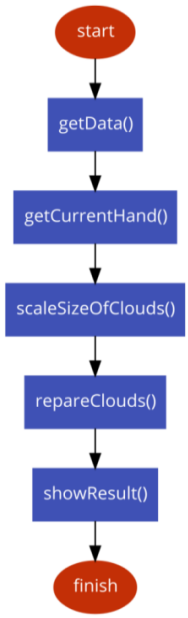

Fig. 4. The general block-scheme of the program.

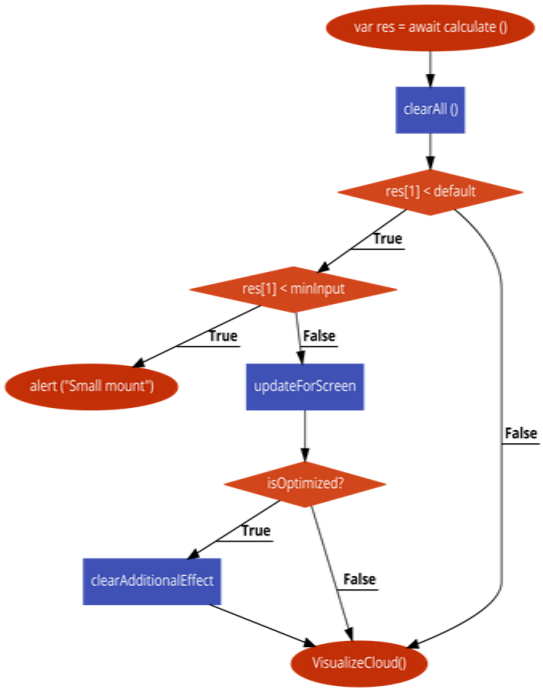

Fig. 5. Degeneration of regular polygons into segments *m*.

4 Results

This application architecture allows you to create a flexible WEB – application quickly. To start working with program you need to follow the link https://emissionvisualizer.herokuapp.com/ First of all, you need to enter data into the appropriate fields. Data will be validated by special function, which shows result for user. The next step is to choose the side of the wind. It is available to choose one of 8 sides. After that you need to click on “Calculate” button to see the results of calculating and visualized cloud (fig. 6).

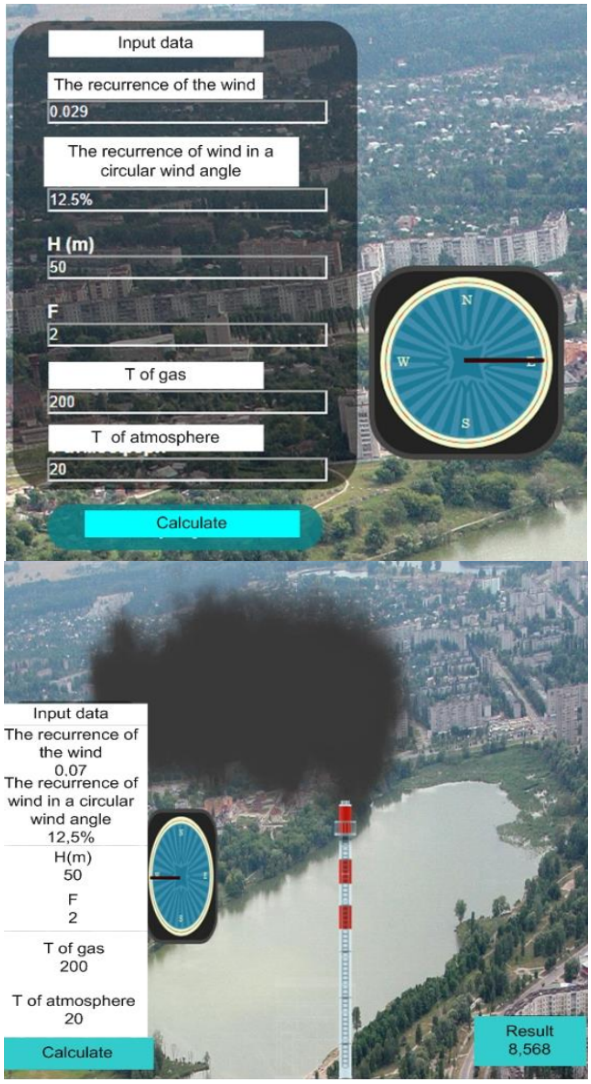

Fig. 6. The appearance of the program.

5 Conclusions

Therefore, different recurrence of wind in different directions causes different range of pollutants spreading from the source of their emission and accordingly influences the peculiarities of the shape of the zone of pollution.

The considered model of estimation of the range of pollutants from the source of their emissions is the basis for the calculation of the sanitary protection zone of the enterprise and used to develop a mobile application (a computer program) for the convenience of calculating the possible impact on a real business entity.

This model provides opportunity to calculate the range of distribution for different clouds. Using it we can show 3D object for the cloud scale analysis.

The next project will be devoted for studying environmental pollution by all chemical factories in our country. The number of photographs of chemical enterprises in various cities of our country will be increased and wind roses for them will be calculated with the help of this application. The next step is the photos will be used as markers for creation AR, which will combine the image of the pipe with which the emission moves with the territory of the city. We can see ourselves at any factory in our country while being at home or in the classroom. The development of this laboratory work will be introduced into the educational process of students of the specialty Environmental Protection Technologies.

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