Results of a pilot experiment-study with continuous monitoring of the atmosphere over an industrial enterprise

O S Logunova¹, V V Kabanova¹, Yu V Kocherzhinskaya¹ and Sh N Ataullayev²

¹Federal State Budgetary Institution of higher education "Magnitogorsk State Technical University named after G.I. Nosov" (FSBEI HE "MSTU named after G.I. Nosov"), Magnitogorsk, Russia
²Bukhara Institute of Engineering and Technology Kayum Murtazaev street, 15 Bukhara, Uzbekistan

* E-mail: logunova66@mail.ru

Abstract. One of the problems of the modern world is to ensure a favorable environmental situation in the field of functioning of large industrial enterprises. Information about the state of the atmosphere over industrial single-industry towns is the most indicative in this period of time. The purpose of the experimental study is to collect and preliminary process information with continuous monitoring of the atmosphere over the enterprise of the metallurgical industry. To collect information, the device of the model was used: Xiaomi Redmi Note 10. As shooting points, the places from which the atmosphere over the metallurgical enterprise can be observed are selected. The paper highlights the need for environmental monitoring, considers ways to collect information in monitoring the atmosphere, methods of pre-processing images to improve their quality and subsequent analysis using computer vision. Parts of the maps of the city of Magnitogorsk with the shooting points and angles marked on them are presented. The course of monitoring the atmosphere over an industrial enterprise is described. The influence of weather conditions on the course of monitoring was revealed. The results of the study of the state of the atmosphere are recorded in the form of photo and video streams.

1. Introduction

The problem of air pollution is one of the global problems faced by mankind. The problem is multifaceted and affects the morbidity of people, negatively affects the flora and fauna, the problem of urban ecology. The importance of this study is extremely high, since every year pollution changes the climate of our planet, which can lead to more large-scale disasters.

Mankind has been studying the problem of pollution of mankind for several centuries. For example, it has been revealed that pollution is divided into natural and artificial. The first type includes volcanoes, forest fires, sand and dust storms. The second type is chemicals, fuel combustion in the energy sector, in industry, in transport [1].

Part of environmental monitoring is the monitoring of the state of the air basin in time and space. In a general sense, ecological monitoring is a system of observations of the state of the environment for assessing anthropogenic impact and predicting further changes in the natural environment, as well as for solving the tasks of monitoring and taking measures if necessary. Environmental monitoring is divided into levels: global (observation of global processes); national (monitoring within the state); regional (covers individual regions); local (observations in hazardous areas, usually directly adjacent
to the sources of pollutants). The work [2] details information on the organization, effectiveness of environmental control systems, describes the classification of pollutants.

In Fig. 1. A scheme is presented, which reflects the three main activities of environmental monitoring (observation, assessment, forecast). The purpose of environmental monitoring is to identify sources of pollution, determine their level of impact on the environment, assess and forecast changes, obtain reliable information about the state of the natural environment to prevent adverse effects [3].

![Figure 1. Scheme of activities of environmental monitoring.](image)

2. Main part

2.1 Analysis of information gathering methods when monitoring the atmosphere over an industrial plant

As part of the work, the authors of the work understand the actions aimed at obtaining a photo and video stream about the state of the object of research at a given time or periods. Information collection is carried out by technical means [4, 5] or by a person. A person is able to independently receive information through study or observation. In the course of such a study, a set of initial expert data is accumulated.

In the case of continuous monitoring of the atmosphere by means of gas analyzers or sampling, important information is the chemical composition of the air and the concentration level of pollutants in order to assess air quality and control the amount of emissions. For example, the work [6] considered the main provisions of the organization of monitoring of atmospheric air in the territory of the Kaliningrad region, during the monitoring daily control was carried out by taking readings from devices and taking air samples, followed by laboratory tests at several posts.

Also, emission control is carried out using unmanned aerial vehicles, video surveillance systems, video shooting, photography, satellite imagery [7], geographic information systems [8]. The article [9] presents a dynamic model describing the stages and methods of using unmanned aerial vehicles that perform environmental monitoring tasks in conditions of external influence. Unmanned aerial vehicles are of great value in monitoring objects in hard-to-reach areas [10, 11].

Video surveillance systems allow you to monitor a certain zone in real time from several angles, displaying a video signal in the form of a video image of the object on the user's screen [12, 13].
2.2 Results of information gathering in continuous monitoring of the atmosphere over an industrial plant

The authors of the work conducted local environmental monitoring in the city of Magnitogorsk. During the study, photo and video shooting was carried out to obtain information.

For monitoring, a mobile device of the model was used: Xiaomi Redmi Note 10. Technical characteristics of the mobile device are given in the table.

| №   | Characteristic               | Meaning                                                      |
|-----|-----------------------------|--------------------------------------------------------------|
| 1   | Country of origin           | China                                                        |
| 2   | Type                        | Smartphone                                                   |
| 3   | Matrix                      | 48 megapixels                                                |
| 4   | Photo Resolution            | $8000 \times 6000$                                          |
| 5   | Zoom                        | Digital                                                     |
| 6   | Flash                       | LED                                                         |
| 7   | Stabilization               | Digital                                                     |
| 8   | 8K video recording          | No                                                          |
| 9   | 4K video recording          | Up to 30 fps                                                |
| 10  | 1080p video recording       | Up to 60 fps                                                |
| 11  | Slow motion                 | 960 fps (720p)                                              |
| 12  | Wide angle lens             | $118^\circ$                                                  |
| 13  | Number of lenses            | 4 (48 MP + 8 MP + 2 MP + 2 MP)                               |
| 14  | Main Lens                   | - 48 MP - Aperture: f/1.8 - Focal length: 26 mm - Pixel size: 0.8 microns - Sensor: 1/2", Sony IMX582 (Exmor-RS CMOS) - Phase AF |
| 15  | Ultra-Wide-Angle Lens       | - 8 MP- Aperture: f/2.2- Focal length: 13mm - Pixel size: 1.14 microns - Sensor: 1/2.8", Sony IMX355 (Exmor-RS CMOS) |
| 16  | Macro Lens                  | - 2 MP- Aperture: f/2.4- Sensor: 1/5", GalaxyCore GC02M1 (CMOS) |
| 17  | Time-of-flight lens         | - 2 MP- Aperture: f/2.4- Pixel size: 1.75 microns           |
| 18  | Video Recording             | 1080p@30fps                                                 |

As points for shooting, four were selected, which allow you to see the state of the atmosphere above PJSC Magnitogorsk Iron and Steel Works. The first point of shooting is Naberezhnaya Street, 1, S. Ordzhonikidze Palace of Culture of Metallurgists. Figure 2a marks this point and shows the directions of photo and video shooting. Emissions from LPC - 11, domain and ESPC - objects of observation. In Fig. 2b and fig. 2c presents typical photographs.
Figure 2. Examples of typical photographs: a – shooting point: Naberezhnaya Street, 1, S. Orjonikidze Palace of Culture of Metallurgists; b – rakurs domna, ESPC; c – angle LPC-11.

The second point of shooting is an alley located opposite the monument "Rear Front". In Fig. 3a marks a dot, shows the angles of photo and video shooting. In Fig. 3b is a typical photograph.

Figure 3. Examples of typical photographs: a – shooting point: an alley located opposite the monument "Rear Front"; b – excursions: domins, ESPC.

The third point of shooting is Lenin Avenue, 68, Magnitogorsk Gipromez, 5th floor. In Fig. 5a is marked with a dot, showing the angles of photo and video shooting. In Fig. 5b is one of the many photographs obtained from this point.

Figure 4. Examples of typical photographs: a – shooting point: Lenin Avenue, 68, Magnitogorsk Gipromez, 5th floor; b – angles: LPC-11, domes, ESPC, mmK territory.
In total, 10 points of m were examined during the pilot experiment, 800 photographs were obtained. Upon completion of the monitoring, the resulting photographs and videos were sorted depending on the point of shooting and the subject.

The images were then pre-automatically processed by some of the methods described in paragraph 2.3. **Image pre-processing algorithms**

For successful recognition of areas in the image during automatic analysis, preliminary processing is performed. The choice of pre-processing methods and their combination depends on the task and the type of image obtained. There are common methods of preliminary processing, which are used in almost any image processing. Each image contains defects, which include: digital noise; excessive or insufficient brightness, contrast; rafocus; distortion, perspective, etc. Digital noise is an image defect consisting in the appearance of pixels of different colors throughout the image, introduced by the electronics of the device. In Fig. Figure 5 shows a photograph containing digital noise.

![Figure 5. View of a photo with digital noise.](image)

There are algorithms for filtering images that suppress digital noise. In the works [14, 15], the authors examine in detail all kinds of filters, for example, averaging filters. A filter based on the calculation of the arithmetic mean of some neighborhood of points to obtain the value of a single point is the simplest among averaging filters. Filters based on ordinal statistics depend on the pre-ranking of area pixel values, the result being the filter response. The behavior of adaptive filters differs from the behavior of averaging filters and filters based on ordinal statistics. It changes to reflect the new image properties obtained by applying the filter.

Image histogram – a graph of the distribution of repeatability of pixel values. Brightness levels cover the range from 0 to 255. To improve and correct the contrast of the image, the histogram is equalized. This algorithm redistributes the brightness values on the histogram. The article [16] compares the algorithms for equating histograms. In Fig. 6. Three images obtained during the monitoring of the atmosphere over the metallurgical plant are displayed: the original photo-graph, the dark and light images, as well as the corresponding histograms.
Figure 6. Images obtained during monitoring and histogram of brightness.

For unfocused images, Wiener filters are used [17].

After the initial processing, the image is ready for the next stage - conversion to grayscale, threshold segmentation, and then to recognition.

Most image preprocessing algorithms are implemented in computer vision libraries, which simplifies processing. The works [14, 18, 19, 20] contain a huge number of different algorithms for pre-processing images, as well as in the works [21, 22, 23, 24, 25] the use of methods and control.

3. Conclusion

During the research process:

1) theoretical and practical developments in the field of environmental monitoring are analyzed and it is obtained that the collection of information on the state of the atmosphere takes place with the help of unmanned aerial vehicles, video surveillance systems, satellite images, as well as photo and video shooting;

2) a pilot experiment was carried out to collect information about the state of the atmosphere over the enterprise of the metallurgical industry, using photo and video shooting, as a result of which 10 points of view were investigated and 800 photographs were obtained;

3) possible image defects, such as digital noise, insufficient or excessive contrast, defocusing and appropriate ways to eliminate these defects, have been studied, and the possibility of using typical image preprocessing algorithms has been determined;

4) methods of pre-processing of images obtained during the monitoring of the atmosphere over an industrial enterprise were applied;

5) it is established that weather conditions affect the quality of the images obtained during monitoring and there are difficulties in determining the optimal angle for obtaining high-quality video material;

6) it is determined that the quality of the obtained images after pre-processing is sufficient for subsequent automatic analysis using computer vision.

References

[1] Nikiforova V A, Podoinitsyna N A and Sahakyan A K 2016 Tr Brat gosud univer. Ser: Nat and Eng Sc 2 192-196

[2] Yakunina I V and Popov 2009 Ecological monitoring: a textbook for students studying in the specialty 280202 "Engineering protection of the environment", as well as bachelors and masters studying in the direction of "Environmental Protection" (Tambov) ISBN 978-5-8265-0864-0
[3] Sedova A P 2007 *Gor inform-an bull* 10 58-61
[4] Shcherbakov V V 2015 *Th and app asp of mod sc* 7-3 147-149
[5] Smirnov P I and Pikalev O N 2017 *Methods of collecting telematic streaming data from vehicles in operation* (Perm) 10-12
[6] Krivosheeva K D 2018 *Organization of environmental monitoring on the territory of the region by the Kaliningrad Center for Hydrometeorology and Environmental Monitoring* (Kaliningrad) 331-334
[7] Butusov O B, Kantyukov R R and Popov D V 2016 *Analysis of the technogenic ecological catastrophe in the area of the gas pipe-line with the help of satellite images* (Yekaterinburg) 268.
[8] Ilyinykh A L 2014 *Use of GIS-technologies for the purpose of monitoring the pollution of the atmosphere of settlements* (Kemerovo) 319-320
[9] Pavlovich A V, Kryukova N A and Efremov V V 2020 *Inform techn in const, soc and econ syst* 4(22) 20-24
[10] Voronin S V 2019 *Unmanned aerial vehicles as means of monitoring the environment* (Kazan) 73-74
[11] Narkevich M Y, Logunova O S and Kornienko V D 2021 *Monitoring the condition of buildings and structures with the help of unmanned aerial vehicles: the results of a pilot experiment* (Magnitogorsk) 33-37.
[12] Patent No. 2690134 C1 Russian Federation, IPC G08G 1/07, H04N 5/76, H04N 21/47. Video surveillance of objects: No. 2018120076: application 30.05.2018: publ. 30.05.2019 / A. E. Bashinsky, I. S., Petriy, I. V., Kazandaev; applicant Municipal State Institution “Tyumengortrans”.
[13] Katasev A S 2010 *Vest Kazan gosudar tekhnich unive im A.N. Tu* 4 145-150
[14] Gonzalez R 2005 *Digital Image Processing* (Moscow) 1072
[15] Novikov A I 2021 *Comp opt* 45(5) 713-720. DOI 10.18287/2412-6179-CO-894
[16] Aleksandrovskaya A A and Mavrin E M 2019 *Vopr n i obraz* 13(60) 20-26
[17] Borisov A A and Tikhonova N S 2018 *Methods of computer processing during video surveillance of the environment* (Moscow) 164-165
[18] Klette R 2019 *Computer vision. Theory and Algorithms* (Moscow) 506 ISBN 978-5-97060-702-2
[19] Narkevich Yu, Logunova M, Kalandarov O S, Romanov P and Khushiev S 2021 *IOP Conf Ser: Ear and Envir Sc* 939(1) 12031 https://doi.org: 10.1088/1755-1315/939/1/012031
[20] Kalandarov P I, Mukimov Z, Abdullaev K, Toshpulatov N and Khushiev S 2021 *IOP Conf Ser: Ear and Envir Sc* 939(1) 012091 https://doi.org: 10.1088/1755-1315/939/1/012091
[21] Narkevich M Yu, Logunova O S, Kalandarov P I, Kalitaev A N, Tokmazov G V, Romanov P Yu and Alimov O 2021 *IOP Conf Ser: Ear and Envir Sc* 939(1) 012030 doi://10.1088/1755-1315/939/1/012030