AI-SUPPORTED SOLUTION FOR PROPOSAL TO IMPROVE INDOOR AIR QUALITY USING WEB APPLICATION AND AIRTHINGS RADON DETECTOR

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Abstract:

The device called View Plus Radon Detector made by Airthings, allows measuring indoor air quality parameters. Measurement results can be accessed through the purpose-built online platform – Airthings Dashboard. The Airthings Consumer API enables our custom-made web application to retrieve the results of the latest measurement. The question arises of how to mitigate the effects of poor air quality parameters.

We propose the use of a web application called Air Quality - AI mitigation advisor. After retrieving the results of the latest measurement, this web application can send these results for assessment to artificial intelligence. AI has the ability to suggest a sorted list of devices with brief explanations or means to improve air quality in the room where the measurement is taken based on the sent question and air quality parameters.

In our work, we provide a description of the system used. We also describe and present the results of an experiment that combines the capabilities of the View Plus Radon Detector, the web application, AI, and statistics with the aim of providing device and means recommendations for improving air quality in the room where the measurement is taken after a series of measurements.

Keywords:

Web Application, React.js, Artificial intelligence, Radon Detector, Mitigation.

INTRODUCTION

This report represents a continuation and enhancement of our previous work titled [1]. In the mentioned paper, we presented a web application that allows displaying the results of the latest measurement by the View Plus Radon Detector device. Solutions in this field typically have three components: detect, mitigation and prediction: In our previous work, we demonstrated the capability of detecting and then displaying air quality parameters. In the work we present here, the focus is on the mitigation component. More precisely, a component for communication with AI will be added to the existing system, which will provide recommendations on how to mitigate the effects of poor air quality based on the posed question and the parameters of air quality from the latest measurement. The system will be explained, and an experiment will also be presented.

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The following overview will provide a brief review of the state of the field. Then, the air quality parameters we analyse will be presented. A brief description of the most important aspects of AI and the capabilities offered by ChatGPT-4 in our case will be provided. The interface and functionalities of the web application will be explained through images and brief explanations, primarily focusing on those parts that are new compared to our previous work. Finally, an experiment will be presented along with corresponding conclusions.

2. PREVIOUS RESEARCH

There are several papers in this field. We will present the most interesting ones below.

"The main objective of this thesis was to develop a solution with IoT technologies, to detect, mitigate and predict radon gas in a home." [2]. The entry into this system is represented by sensors, with an Arduino board used as the microcontroller. Web services are part of the system, and a fan is used as an actuator. According to the authors, this method allows reducing radon levels by up to 93%.

"This work presents a fully automated, low-cost indoor air quality control system that can monitor temperature, pressure, humidity, total volatile organic compounds (TVOC), and radon concentration. Using the radon concentration as an air quality measurement, we created a prediction algorithm. The system uses those predictions to control the ventilation system automatically." [3]. This relatively inexpensive IoT solution provides a graphical interface, as well as predictive capabilities, enabling control over the actuators of the ventilation system.

Not all solutions include all three mentioned components. For example, [4] is the solution that monitors radon levels in public buildings with notification support but does not include mitigation and prediction options. A more advanced solution that also addresses public buildings is provided in [5] where the mitigation component is supported.

The proliferation of AI lately has provided the opportunity to use AI in the field of air pollution monitoring and control. "This study seeks to improve the monitoring and control of water and air pollution by incorporating ChatGPT, an advanced language model developed by OpenAI." [6]. Here, the role of ChatGPT is emphasised as a link between complex data analytics, machine learning algorithms, and ultimately people who represent decision-makers.

3. AIR QUALITY PARAMETERS

"View Plus Radon Detector offers the possibility to measure seven parameters of air quality (concentration radon, PM1, PM2.5, VOC, temperature, humidity and pressure). By looking at the values of these parameters, we can get to know the quality of the air we breathe in a closed space and, if necessary, we can take actions to improve the air quality using different methods and devices." [1]. In the same source, the mentioned parameters are explained in more detail. These are the parameters we use when forming questions directed to AI. Since we are focused on addressing poor aspects of air quality, we do not include values of parameters that are within normal limits as part of the AI questions. Threshold values for parameters are provided in [7]. The description of the detector and API used here has already been detailed in our paper [1], which serves as a direct basis for the solution we propose in this paper.

4. ARTIFICIAL INTELLIGENCE (AI) AND CHATGPT

Our solution is based on combining the capabilities offered by Internet technologies, artificial intelligence, and human input. One of the definitions of AI goes like this: "Artificial intelligence, or AI, is technology that enables computers and machines to simulate human intelligence and problem-solving capabilities." [8]

In order to harness the capabilities offered by AI, it was necessary for us to choose a solution where interaction between AI and the rest of our system is possible. We decided to utilise the capabilities offered by GPT.

"We characterise GPT-4, a large multimodal model with human-level performance on certain difficult professional and academic benchmarks. GPT-4 outperforms existing large language models on a collection of NLP tasks, and exceeds the vast majority of reported state-of-the-art systems (which often include task-specific fine-tuning). We find that improved capabilities, whilst usually measured in English, can be demonstrated in many different languages. We highlight how predictable scaling allowed us to make accurate predictions on the loss and capabilities of GPT-4." [9]. It has already been shown in some works like [10], [11] and [12] that GPT-4 is capable of answering questions from a variety of fields with relatively good success, although it does make mistakes, so human expert supervision is still needed. What is specific to this paper in relation to the mentioned above is that now GPT-4 has communication with the web application.

5. WEB APPLICATION

The web application used in our solution represents an upgraded version of the web application from our previous work [1]. For this reason, we will focus only on the changes in appearance and functions that have been added. After logging in, as described in [1] the initial screen of the web application is displayed. In comparison to the previous solution, there is a change in the sense that the measured temperature is now displayed instead of the Hub item.

Additionally, the icons and labels have been slightly graphically modified and adapted to the needs of this work. Another change is the AI button that appears after pressing the synchronisation button. The main screen is shown in Figure 1 on the left. By pressing the AI button, the user gets the extended screen (Figure 1, right). Here, the posed question and the obtained answer can be seen in textual form. To return to the main screen, there is a back button at the bottom.

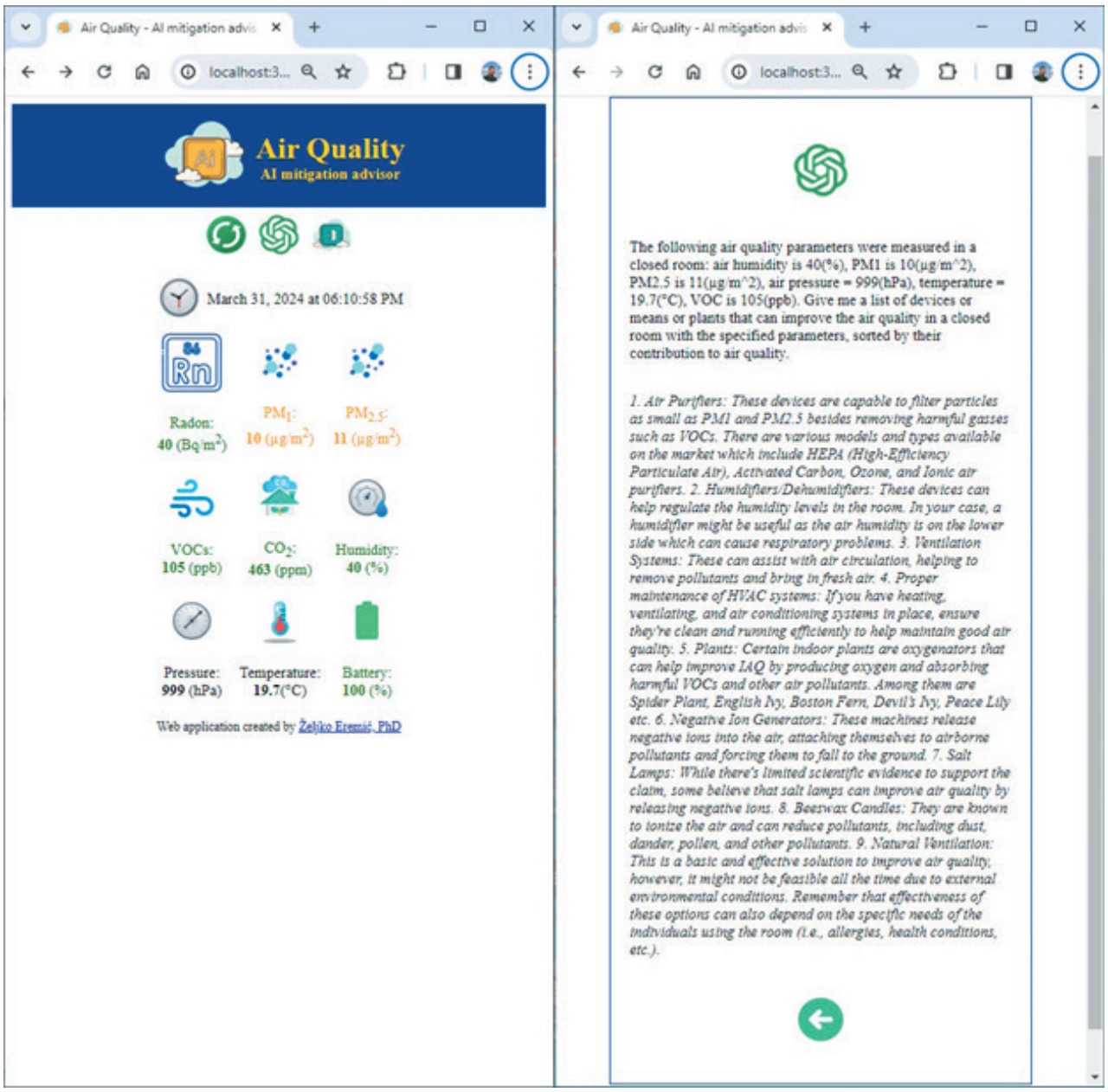

Figure 1. First (left) and second (right) screen of the web application.

6. EXPERIMENT

The experiment was conducted from May 19, 2024 to May 25, 2024. During this period, 21 measurements were performed. The measurement process involved pressing the synchronisation button first to retrieve the latest measured data. If at least one of the parameters was outside the normal range, the next step was to press the AI button, which led to transitioning to the screen displaying the question and answer. The answer contained a sorted list of devices or means that AI suggests for improving air quality, taking into account the measurement results. We scored the suggestions so that the first suggestion received 10 points, the second 9 points, and so on. The measurement results are shown in Table 1. Before that, it is necessary to provide a legend for the columns of this table:

- i1 - Radon (Bq/m^2);
- i2 - PM1 ($\mu g/m^2$);
- i3 - PM2.5 ($\mu g/m^2$);
- i4 - VOCs (ppb);
- i5 - CO_2 (ppm);
- i6 - Humidity (%);
- i7 - Pressure (hPa);
- i8 - Temperature (°C);
- g1 - Air Purifiers, Activated Charcoal/Bamboo Charcoal Air Purifiers, Activated Charcoal bags, Activated Carbon Filters, HEPA Filters, Activated Charcoal Filters;
- g2 - Ventilation, Heat Recovery Ventilators (HRV), Exhaust fans, Natural ventilation, Regular Ventilation, Ventilation systems;
- g3 - Air Conditioning, HVAC systems with high-quality filters, Heat Recovery Ventilator, Temperature Regulation;
- g4 - Indoor Plants, Boston Fern, Snake Plant, Spider Plant, Peace Lily Plant, Houseplants;
- g5 - Humidifiers, Dehumidifiers;
- g6 - Beeswax Candles, Salt Lamps;
- g7 - Essential Oil Diffusers;
- g8 - Regular Cleaning;
- g9 - Air Quality Monitor, Carbon Monoxide Detectors and Alarms; and
- g10 - CO_2 Scrubbers.

Table 1. Measurement results.

Date Time	i1	i2	i3	i4	i5	i6	i7	i8	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
19-03-24 13:00	22	**11**	**11**	**256**	**811**	**27.41**	1011	20.70	10	7		6	8					9
19-03-24 18:20	22	**18**	**18**	138	499	**26.38**	1013	20.20	10	8		7	9		6			
19-03-24 23:05	22	**26**	**26**	48	491	**26.08**	1014	19.91	10	7		8	9		6			
20-03-24 09:25	35	**23**	**23**	**267**	725	**27.62**	1016	20.07	10		8	7	9		6			
20-03-24 11:50	37	**15**	**15**	**304**	542	**27.63**	1014	19.95	10	8	7	6	9	4	5			
20-03-24 19:13	37	**25**	**26**	159	487	**28.94**	1014	19.87	10	8		7	9		6			
21-03-24 09:08	21	**35**	**37**	**332**	741	32.14	1012	19.83	10	8		7	9	5	6			
21-03-24 14:43	26	**16**	**16**	**465**	639	32.02	1009	19.43	10	7	8	6	9		5			
21-03-24 20:45	22	**52**	**54**	**339**	524	32.92	1009	19.35	10		8	7	9	4	5	6		
22-03-24 07:53	31	**43**	**49**	131	721	31.69	1011	19.50	10	7		8	9	5	6			
22-03-24 14:15	39	**19**	**20**	**394**	612	34.80	1008	18.93	10	7		8	9	5	6			
22-03-24 20:35	42	**26**	**26**	**308**	515	37.53	1007	19.00	10	8		7	9	6				
23-03-24 09:43	47	**35**	**41**	157	478	36.75	1003	19.72	10		8	7	9		6			
23-03-24 14:10	49	**13**	**14**	**259**	455	37.94	998	19.20	10	6	5	9	8		7			
23-03-24 21:15	58	**18**	**18**	**253**	461	38.62	996	18.54	10	7	8	6	9	3	5		4	
24-03-24 18:33	31	**12**	**12**	148	465	37.27	999	19.95	10	6	8	7	9		4	5		
24-03-24 20:18	31	**14**	**14**	122	466	36.97	999	19.83	10	4	8	7	9			5	6	
24-03-24 23:48	32	**11**	**11**	52	484	35.93	998	19.12	10		7	8	9		6		5	
25-03-24 09:05	32	6	7	**609**	**943**	38.67	1001	19.95	10	8	6	9	7		4	3		5
25-03-24 19:38	32	**26**	**30**	**165**	503	34.14	1001	19.69	10	5	9	8	7	4	3	6		
25-03-24 22:18	30	**28**	**29**	**159**	498	34.48	1002	19.50	10	7	6	9	8					
Total	/	/	/	/	/	/	/	/	210	118	96	154	182	36	92	25	15	14

In the columns representing air quality parameters i1 – i8, values outside the normal range are indicated in bold formatting. Columns with the prefix "g" (group) represent the suggestions provided by AI and contain the points we assigned based on their position in the AI-generated response. Sometimes, there are synonyms in AI responses, so in such cases, grouping was performed under one of the names, for example, "Indoor Plants" and "Houseplants". The purpose of this grouping is to avoid the possibility of scattering points and thus obtaining an incorrect final result. Grouping was not only based on whether the terms were synonyms, but also on whether the effect of their work was similar or the same. We can see the measurement results in Table 1.

The measurement showed that in the observed sample, we most commonly have deviations in the input values when it comes to PM1 and PM2.5 particles. Following them, deviations occur in the values for VOCs and Humidity, while to a lesser extent, there is deviation in CO2 values. The remaining input values were within normal limits. The recommendations we received from AI largely depend on the values of the input parameters. We grouped the recommendations based on the similarity of the effects they can have on improving air quality, and they are shown in columns g1 - g10 in the table.

After summing up the assigned points in our experiment, the following suggestions for improving air quality in the room where the experiment was conducted were obtained:

1. g1 - Air Purifiers, Activated Charcoal/Bamboo Charcoal Air Purifiers, Activated Charcoal bags, Activated Carbon Filters, HEPA Filters, Activated Charcoal Filters (210 points);
2. g5 - Humidifiers, Dehumidifiers (182 points); and
3. g4 - Indoor Plants, Boston Fern, Snake Plant, Spider Plant, Peace Lily Plant, Houseplants (154 points).

All other groups of recommendations received a lower number of points. What is characteristic is that g1 received the maximum of 210 points, indicating that the installation of some of the recommended devices from this group (Air Purifiers, Activated Charcoal/Bamboo Charcoal Air Purifiers, Activated Charcoal bags, Activated Carbon Filters, HEPA Filters, Activated Charcoal Filters) are firmly recommended for improving air quality in this room. It should be emphasised once again that these recommendations are based on one experiment in one room, and the results could be different if the input data were different in a new experiment.

7. CONCLUSION

In the paper presented, a solution is proposed that enables obtaining a list of suggestions for improving air quality in an enclosed space through a combination of detectors, Internet technologies, AI, and statistical processing. Previous research in this field has been reviewed. Definitions of AI have been provided, and ChatGPT-4 has been introduced as our tool for accessing the capabilities offered by AI. The features of the web application used in our experiment have been presented. Finally, an experiment has been conducted, resulting in a list of suggestions for improving compromised air quality in an enclosed space.

This paper contains an original system developed specifically for this purpose, as well as presenting an experiment. Further directions of development include the possibility of creating a third component that such systems have, namely prediction.

8. REFERENCES

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