Outdoor Misting System

Ronald T. Soriano (DIT)
Iloilo Science and Technology University, Burgos St. Lapaz Iloilo City, Philippines
cuzsoriano@yahoo.com

Asia Pacific Journal of Multidisciplinary Research
Vol. 8 No.2, 94-100
May 2020
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com
ASEAN Citation Index

Date Received: October 16, 2019; Date Revised: April 23, 2020

Abstract-*This study seeks to combine the function of misting systems as an important tool for promoting better conditions in controlled spaces such as industrial warehouses, plantations, communities, and outdoors especially its ease of control. This study is also developed to make the misting system's operation more convenient to the user that it can be operated and monitored even from faraway places provided there is a network connection available. It will also record the humidity of the area for the entire year. Aside from having full control of the operation, this study is also developed to protect the efficiency of the misting machine and all its components by automatically checking on the system's operational health upon user's log-in. The system was further evaluated by both Information and Communication Technology (ICT) professionals and end users to see the conformance of the application to the software standards based on ISO 25010 which yield a result to a value described as "Excellent" and that the overall characteristics of the system passed the ISO 25010 standards after conducting a series of runs.*

Keywords: *Misting System, Fogging System, Humidification, Remote Access Control, Web Application*

INTRODUCTION

The most common problems faced by many people especially in a hot country like the Philippines is the sticky feeling they get while at work or play during the Summer months. Hot, humid summer days can feel unbearable sometimes [1]. The combination of warm temperature and high humidity give rise to high sensible temperature throughout the archipelago. It is especially uncomfortable during these months, when temperature and humidity attain their maximum. Humidity can make the temperature feel warmer, as our sweat is slower to evaporate. Between the months of March and September many may suffer from the mildest to the most severe symptoms of heat stroke [2]. The humidity is a huge factor of that very uncomfortable feeling when a person will be sweating but the sweat won't be drying on the skin. Prolonged sweating draws a lot of water from the bloodstream. It reduces its capacity to deliver nutrients, clear out wastes, lubricate joints and cool a person. If the body continues to lose fluid, a person is likely to experience increasingly severe symptoms of heat stroke which may be characterized by general discomfort, loss of coordination and stamina, weakness, poor concentration, irritability, blurry vision, headache, dizziness, nausea, confusion and unconsciousness [3]. Moreover, mosquitoes are a significant problem in many parts of the world especially when relative humidity is high. These insects not only create a hazard for livestock and farm animals, but also for humans in residential areas. Mosquitoes are, for example, the primary carriers of dengue, malaria and other viruses. Personal sprays and citronella candles and torches are often used to combat the pests. However, such measures are often inadequate during certain times of the year when mosquito activity is high. Propane-based attractor devices are also known, but their effectiveness is debatable [4]. A variety of applications of misting systems are now readily available on the net and market in order to suit the needs of users. One example is Closed-loop mosquito insecticide delivery system and method. Serious infections such as malaria, dengue fever and encephalitis are carried by mosquitoes. In many places around the world, ground vehicle mosquito spray systems are applied to get rid of mosquitoes. In the Philippines the most common term is fogging. It is the method of spraying mist (usually a mixture of water and mosquito repellant chemicals) into the atmosphere of a certain area to drive away mosquitoes.

One major problem associated with presently available ground vehicle mosquito spray systems and the fogging system is that the local weather conditions are not automatically considered as there are no

sensors that will function before and during the spray process. Everything is up to the decision making of the person in charge of spraying or fogging, this has occurred in 1999 in New York City [5].

The study Outdoor Misting System was designed and developed to automate misting system and control it remotely. Unlike other misting system, this Outdoor Misting System was designed to monitor and record humidity and temperature in the surrounding area. It will also save the highest humidity record for each day or week for the entire year according to user preset period. The user of the system needs to set the humidity range to be maintained by the system. The system will monitor the status of the humidity sensor, compare its data to the system's preset value. If the obtained humidity is lower than the minimum set humidity range, the system will automatically turn on (spray mist) to maintain the humidity range set by the user. The system will automatically shut off once the set maximum range of humidity is reached.

In addition, the system can also monitor the status of the temperature and compare its data to the user's preset value. If the temperature is greater than the value set by the user, the misting system will automatically turn on. But once the temperature lowers down to the safe value set by user, the system will automatically shut off the misting operation.

OBJECTIVES OF THE STUDY

The study aims to design, develop and evaluate an Outdoor Misting System. Specifically, this study aimed to design and develop outdoor misting system; and evaluate the automated misting system in terms of Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, and Portability.

METHODS

The researcher follows the Prototyping methodology to conduct the study. According to Dennis, Wixom, and Roth [6], a system prototype is performed by analyzing, designing and implementing the system.

In the planning phase, the researcher performed the preliminary investigation to identify the nature and scope of the study. The researcher conducted a feasibility study that reviews the operational, technical, schedule and economic requirements of the study. Moreover, the researcher conducted the review of various related literature and studies that helped the researcher in identifying the strengths and the opportunities that supported the design of the proposed study.

During the analysis phase, the researcher designed the logical model of the system. The researcher established the functional and nonfunctional requirements of the system to determine what the system must do. Fact finding was done during this phase where the data and process model was based.

The researcher during the system design phase designed the necessary diagrams that helped represent the study to the target users as well as readers. The researcher also designed the user interfaces of the system to determine the necessary input, process and output of the system.

The system was coded using PHP and Python and tested to check for program errors. The system was continually developed until the necessary requirements have been achieved.

During the implementation phase, the researcher tested the system and had the intended user test the system to gather some recommendations and suggestions from them. This continually took place, until the client was satisfied. When the system satisfied the client's needs, the system was then implemented for use.

The functionality of the system was described using Use Case Unified Modelling Language (UML). UML diagram according Shelley, Cashman and Roseblatt [7], was a popular technique for documenting and modeling system. The UML used a set of symbols to represent graphically the various components and relationships within a system.

On the other hand, the Use Case Diagram of the system was shown in Figure 1. As stated in uml-diagrams.org [8], Use case diagram was also called behavior diagrams that were used to describe how the actor interacted with the system or also called use cases. Each use case should provide some observable and valuable result to the actors or other stakeholders of the system.

The system had two actors called the system administrator and users. The administrator had several activities in the system. These included managing the user's account, generating log report, managing humidity sensor and managing the schedule.

In managing the user's account, the administrator could add user, edit and delete accounts and at the same time could change the username and password of an individual account. It could also generate a system log as to when the system was used and who used it.

In managing the schedule, the administrator could set a schedule as to what date and time the system would operate and the period of time it should operate.

The administrator could also set the humidity range to be maintained by the system. The operation of this process was dependent on the data given by the humidity sensor rather than using date and time as inputs.

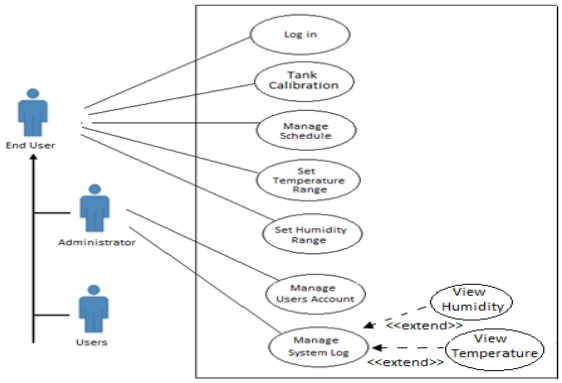

Figure 1. Use Case Diagram of the System

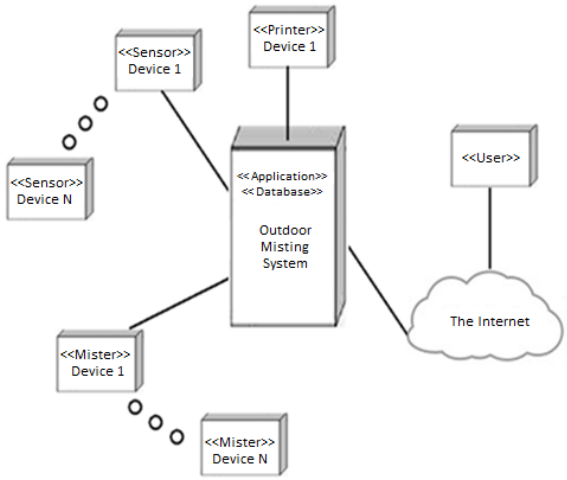

Figure 2. Block Diagram of Device Interconnections

The end-user could log in to the system and manage the schedule of operation of the system, could input a schedule using the date and time and at the same time could view, change and update the schedule and interval of spray time.

The system would first monitor the status of tank whether or not the water was enough to operate the system. Tank calibration could also be done by the measure of water level in the tank and not the volume of water in it. The system would not operate if the water level in the tank was below 5%. This setting was necessary in order to protect the machine.

Aside from entering the schedule, the user had an option to input the humidity range so that the system could operate automatically based on the input range entered by the user. This time the system was responsible for maintaining the humidity of the area based on the result provided by the humidity sensor.

The system was evaluated using the white box and black box testing. According to Williams [9], black box testing was also called functional testing. This was a testing technique that ignores the internal mechanism of a system and focused only on the outputs generated by the system. The software tester should not evaluate the source code of the system and the tester only knew the functional requirements of the system. On the other hand, white box testing was a testing technique in which the evaluator of the system knew the source code and the testing parameters of the system. White Box Testing was also called structural testing and glass box testing hence the evaluator took into account the internal mechanism of a system.

The researcher invited several potential system user to evaluate the system for the black box testing. These respondents were not knowledgeable of the codes and database design of the system. However, there respondents could appreciate the functionality, usability and purpose of the study. The respondents for black box testing might include a business owner, a manager, home owners or anybody in the community who were willing to evaluate the system.

To test the system using White box testing, the system's overall performance with regards to its conformance to the set of standards set in ISO 25010 was evaluated by Information and Communications Technology (ICT) experts using the International Standards Organization's (ISO) 25010 eight quality characteristics including Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability and Portability.

The proponent used the Descriptive Statistics to describe the observation of the respondents towards the evaluation of the system based on ISO 25010 and the evaluation of the end user towards the functionality and usability of the study. Descriptive statistics involved gathering data that described events and then organized, tabulated, depicted, and described the data collection [10]. Using descriptive statistics, the researcher described the report summary or the collected data using mean.

To determine the respondents of the study, the researcher used a purposive sampling which involved the choice of subjects who were most advantageously placed or in the best position to provide the information required being chosen at any stage during the sampling process. They could reasonably be expected to have expert knowledge by virtue of having gone through the experience and processes themselves and might perhaps be able to provide good data or information to the researcher [11].

Using purposive sampling, the researcher selected 35 potential end users of the system and 12 experts from the Information and Communications Technology (ICT) whose solid educational background, work experience and integrity could assure for the correct and clear evaluation of the system.

The questionnaire was composed of five options in which the respondents could use to rate the acceptability and functionality of the system's output. This questionnaire was based on ISO/IEC 205010:2011. To rate the conformance of the system based on ISO 25010 a five rating scale with corresponding description was used as follows: Excellent (5), Very Satisfactory (4), Satisfactory (3), Good (2) and Poor (1).

RESULT AND DISCUSSION

This research was evaluated based on ISO 25010 eight (8) Software Quality Standards. All eight (8) quality standards were used by both Information and Communication Technology (ICT) professionals and end user to evaluate the conformance of the application to the software standards as set by ISO as shown in Table 1.

Table 1. Summary of ISO Evaluation of Outdoor Misting System

Characteristics	End Users		IT Experts		Entire Group	
	M	VI	M	VI	M	VI
Functional Suitability	4.9	E	4.9	E	4.9	E
Performance Efficiency	4.6	E	4.5	E	4.55	E
Compatibility	4.88	E	4.55	E	4.71	E
Usability	4.69	E	4.67	E	4.68	E
Reliability	4.84	E	4.77	E	4.8	E
Security	4.45	E	4.55	E	4.50	E
Maintainability	4.8	E	4.88	E	4.84	E
Portability	4.79	E	4.77	E	4.78	E
Weighted Mean:	4.74	E	4.70	E	4.72	E

The result of the evaluation of the outdoor Misting System operating performance in terms of functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability and portability as evaluated by two groups of respondents, the end users and the IT experts. The grand mean as to the evaluation of the end users is 4.74 (Excellent), for the It experts is 4.70 (Excellent) and a mean rating of 4.72 (Excellent) when taken as a whole. This simply means the system is superior in its operating performance as evaluated by both respondents. This implies that the automated misting system has conformed to the highest degree with the software quality requirements of IS0/IEC 25010 as enumerated by ISO25000.com [12] that software or system product should possess high level of conformance to the standard.

The functional suitability characteristic was evaluated and given a mean rating of 4.90 which is excellent by the end users and 4.9 which is also implied needs when used under specified condition; it covers all the specified task and user objectives. The system also provides the correct results with the needed degree of precision and facilitates the accomplishment of specified task and objectives. This excellent by the IT experts and mean rating of 4.9 as a whole which is excellent, the highest rating a system can get which is the strength of this system? The result implies that the system has provided the users the appropriate functionalities expected of a document management system in sending and receiving of documents.

In terms of performance efficiency evaluation of the system, the end user gave a rating of 4.60 which is excellent, the IT experts has given the highest rating of 4.50 which is also excellent and a mean rating of 4.55 as a whole. This is an indication of the system's outstanding operational performance relative to the amount of resources used under stated condition. This also means that the response and processing time and throughput rates of a product or system, when performing its functions meets requirements and that the maximum limits of a product or system parameter meets requirements. The respondents has seen how the system performs its function efficiently during the automatic and scheduled operation of the misting system.

The compatibility characteristic of the system rated the highest by the end user with a mean rating of 4.88 which is excellent, the IT experts gave a mean rating of 4.55 also excellent and 4.71 as a whole

which is again excellent. This means that the system can exchange information with other products, systems or components, and/or perform its required functions while sharing the same hardware or software environment and can perform its required functions efficiently while sharing a common environment and resources with other products without detrimental impact on any other product, the system can interoperate with two or more systems, products or components, can exchange information and use information that has been exchanged. The evaluators appreciates that since the system is a web application and is running using a browser, one can still work with other task with other applications without rendering a problem with the system and vise-versa. This conforms to the idea of Aceproject.org [13] stating that systems compatibility is related to the issue on system integration. The various system components must be compatible in order to share data between system's component and interfaces. In this context, compatible means sharing compatible hardware, operating systems and software.

The evaluation of usability characteristic of the system proves that the system is indeed usable. The end users rated the system 4.69 which is excellent, the IT experts rated with mean rating of 4.67 though lower but still very satisfactory and an over-all rating of 4.71 which is excellent. This implies that the system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. The users can recognize whether a product or system is appropriate for their needs. The system has attributes that make it easy to operate, control and protect users from making errors. The end users acknowledge the attributes of the systems to be usable while the IT experts has reservation with how the system address user error protection though have given a very satisfactory rating. The findings corroborates with the idea of Nichols and Twindale [14] who stated that user's involvement at the level of identifying software bugs or suggesting new features has been a major factor in every software development success. Hence, these suggestions contributed to the overall usability of the system.

The Reliability characteristic of the system was evaluated 4.80 mean rating as a whole, which is excellent. The end users rated it with 4.84, which is excellent while IT experts gave a mean rating of 4.77 still excellent. This simply means that the system performs specified functions under specified conditions for a specified period of time and meets needs for reliability under normal operation. The system can be accessed and operated as intended despite the presence of hardware or software faults.

The security characteristic of the system was evaluated with 4.50 over-all rating which is excellent. The end user was very satisfied with the security features of the system that it gave a mean rating of 4.45, which is very satisfactory, while the IT experts gave a rating of 4.55 which is excellent. The results showed that the system protects information and data so that the persons or other products or systems have the degree of data access appropriate to their types and levels of authorization, ensures that the data are accessible only to those authorized to have access and prevents unauthorized access to, or modification of computer programs or data. Actions or events can be proven to have taken place so that the events or actions cannot be repudiated nor altered later. The evaluators have seen how the system implements its authentication and authorization features when the user access the system it verifies first if the provided username and password match the data in the database and after verification, the system identifies the authority of the user in using the system such as the privilege given to the user. This conforms to the idea of Hu and Scott [15] who said that security plays a large role in software development hence without it the existence of a software is vulnerable to many different types of attacks such as leaks of data, alternation of data, and unauthorized access to data. Building a secure software involves a number of different processes but security awareness and implementation are the most important ones among them.

Maintainability characteristic of the system was evaluated by the end user as excellent with a mean rating of 4.80, while the IT expert rated it with 4.88, also excellent. This makes the over-all rating of f 4.84, again excellent. This makes the system highly maintainable, which means that the system can be modified by the intended maintainers. It is composed of discrete components such that a change to one component has minimal impact on other components. It is reusable and possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified. The system can be effectively and efficiency modified without introducing defects or degrading existing product quality, which test criteria

can be established for a system, product or component and test can be performed to determine whether those criteria have been met.

The portability characteristic of the system was evaluated with a mean rating of 4.78, which is excellent as a whole. The end users viewed the system's portability as excellent with a mean rating of 4.79 and the IT experts also recognized the excellent portability setup of the system by rated it with 4.77, also excellent. This excellent rating to the portability of the system by both groups of evaluators only shows that the system is highly portable, this means that the systems shows high degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another. It can be adapted for different or evolving hardware, software or operational or usage environment, can be successfully installed and/or uninstalled in a specified environment. It can replace another specified software product for the same purpose in the same environment. The evaluators understand that since the system is a web application and is running using a web browser, they can utilize the system anywhere, anytime using any browser for as long as they are connected to the internet. The experts understand that the system is implemented only once at the application server level and that the workstations are just accessed to the server using system. Any problem with the system is fixed at the application system level. This corroborates with the study published by Mooney [16] that states a software unit is portable across a class of environments to the degree that the cost to transport and adapt it to a new environment in the class is less than the cost of redevelopment.

CONCLUSIONS AND RECOMMENDATION

Based on the results as earlier presented, the system was found to be in compliance to all its specified requirements and objectives. These include maintaining a database of personal profiles; enable the user to set a schedule for the operation of the outdoor system; make the system operate automatically based on the humidity and temperature of the area and create a system operations log; record relative humidity for a period set by the user. Based on the evaluation of respondents from the Information and Communications Technology sector and potential end users the system is excellent in all the eight software quality characteristics as outlined by ISO 25010.

This study has been developed to enable the operation of an outdoor misting system remotely and conveniently. However, it did not support the monitoring of water source. Therefore the researcher recommended to future researchers to include the monitoring of water source in the design and development of the outdoor system to make it more secure and avoid failure of hardware devices. Moreover, it is also recommended for future researchers to make a study on how to improve the security of the system since during evaluation security features of the system was given the lowest rating by the evaluator and thus needs to be improved.

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