Automated Misting System

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Abstract- *The methodology within 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 for controlling dusts, plantations for humidification, communities for fogging and outdoors for cooling. 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 as long as there is a network connection available. As soon as the user logs into the web, the user can have full control of the system's operation and schedule. Although the system cannot monitor the water supply getting into the tank but it can still operate safely by not allowing the system to work under low water level. This study seeks to stress that misting systems are important not just for a certain use but for a variety of applications as well and that they are already accessible over the net which makes them more convenient for users to operate. The system was further evaluated based on ISO 25010 which yield a result to a value described as "Excellent". The result implies that the overall characteristics of the system passed the ISO 25010 standards.*

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

INTRODUCTION

The highest average temperature of the Philippines 1853 to 2015 is 29.16 degrees /celcius [1].The reported daytime temperature of the Philippines is much higher than the required temperature to grow certain plants such as Cole Crops like Cabbage, Cauliflower and Broccoli which only requires 18 to 29 degrees Celsius, Onion bulb which requires 21 to 23 degrees Celsius and tomato which requires 23 to 26 degrees Celsius [2]. The data shows that growing these agricultural products in the Philippines would require certain intervention since these plants are unsuitable to the Philippine climate.

Moreover, according to Ju and Lin [3], the growth of poultry products is also affected by the poultry houses temperature. Thermal stress could affect the growth of the broilers, thus, temperature control management should be made available inside the poultry houses such as the use of cooling system. When temperature is high, one can adjust the ratio of the sensible heat to latent heat in air by using an evaporative cooling technology which is usually a misting cooling system.

A misting system according to Pavlik [4], uses elements having multiple functions, and integrates the mist producing nozzles and conduits with other components so that the misting system does not detract from the aesthetics of the surrounding environment. Most of the time, misting system includes spraying water in a nozzle with tiny opening and is usually designed with high pressure pump, motor, atomizing nozzles, and plumbing. Misting system are typically used in greenhouses, vegetable growing and storing, wine barrel, storage, poultry houses, Textile/Paper Processing, and lumber conditioning.

Misting systems have been in existence for several decades now and its applications have been varied many times and in many ways. A lot of them have their functions and controllers changed over and over again to suit the needs of the users but none has existed with a more user-friendly scheduling system and a remote access control via a network connection.

Some previously existing misting systems were developed for specific applications such as the boat misting system for cooling occupants of the boat or houseboat developed by Williamson [5].The water of this misting system was taken from where the boat floats. The misting system was used to provide cooling system in the boat using a very fine aerosolized water spray. The misting system control the temperature within the boat and provides cooling effects to its occupants.

Another study about misting system was also conducted in 2003 by Sylvia [6] in which the misting

system was placed inside a vehicle. This misting system was developed to create a refreshing environment to its passengers during hot climates. The system was designed with a water pump that uses a connector for splicing into the water line of a vehicle to create mist. The vehicle has a water reservoir, a misting nozzle and an air ports.

Ju and Lin [3] designed and developed a misting system that can be used inside poultry houses. The misting system was installed in a poultry house to investigate the evaporative fraction of the mist-spraying system in open-type poultry houses. It is found out that the misting system could provide relieve to broilers from thermal stress during spraying operation. This study also found out that the best way to increase the evaporative fraction of a misting system was to increase the spraying pressure of a nozzle and reducing the particle diameter of mists.

Aggarwal and Singh [7] developed a misting system for summer and in-house Shelter of dairy animals. High temperature causes heat stress to dairy animals that may incur adverse losses to the animal's productivity. In this study, mister and sprinklers were found to improve milk production and reproductive efficiency of dairy animals regardless of high temperature in the outside environment.

Moreover, misting system can also be used inside green houses for maintaining its operation. According to Anderson [8], misting system is important in greenhouses since they play an important role in growing seeds and vegetative plants. The purpose of misting system inside greenhouses is to deliver low volume of water that is basically enough to propagate vegetative plants and germinating seeds.

Given the different aforementioned prior art of the study which shows the various uses of misting system, the study Automated Misting System was designed and developed to automate misting system and control it remotely. Unlike other misting system, the Automated Misting System was designed to monitor and record humidity and temperature in the surrounding area. 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. Once 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 Automated Misting System. Specifically, this study aims to design and develop automated 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 [9], a system prototype is performed by analyzing, designing and implementing the system.

In the planning phase, the researchers perform the preliminary investigation to identify the nature and scope of the study. The researcher conducts a feasibility study that reviews the operational, technical, schedule and economic requirements of the study. Moreover, the researcher conducts the review of various related literature and studies that will help the researcher identify the strengths and the opportunities that will support the design of the proposed study.

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

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

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

During the implementation phase, the researcher tested the system and have the intended user test the

system to gather some recommendations and suggestions from them. This will continually take place, until the client is satisfied. When the system satisfies the client's needs, the system is then implemented for use.

The functionality of the system is described using Use Case Unified Modelling Language (UML). UML diagram according Shelley, Cashman and Roseblatt [10], is a popular technique for documenting and modeling system. The UML uses 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 is shown in Figure 1. As stated in uml-diagrams.org [11], Use case diagram is also called behavior diagrams that are used to describe how the actor interacts 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.

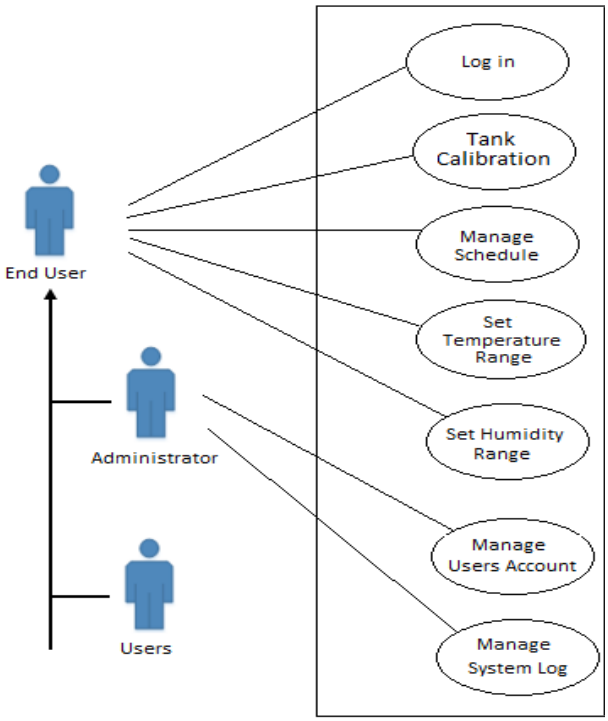

Figure 1. Use Case Diagram of the System

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

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

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

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

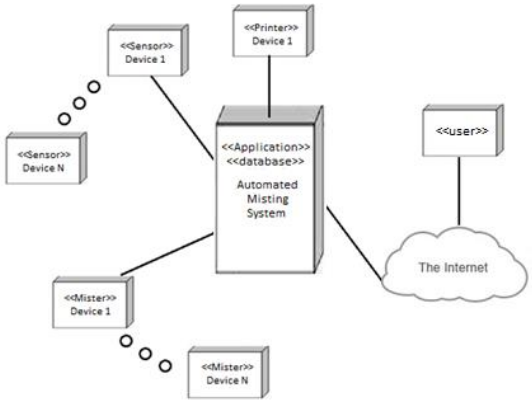

Figure 2. Block Diagram of Device Interconnections

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

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

Aside from entering the schedule, the user has an option to input the humidity range so that the system can operate automatically based on the input range entered by the user. This time the system is 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. Black box testing according to Williams [12], is also called functional testing. This is a testing technique that ignores the internal mechanism of a system and focuses only on the outputs generated

by the system. The software tester should not evaluate the source code of the system and the tester only knows the functional requirements of the system. On the other hand, white box testing is a testing technique in which the evaluator of the system knows the source code and the testing parameters of the system. White Box Testing is also called structural testing and glass box testing hence the evaluator takes into account the internal mechanism of a system.

The researcher invited several potential system users to evaluate the system for the black box testing. These respondents are not knowledgeable of the codes and database design of the system. However, there respondents can appreciate the functionality, usability and purpose of the study. The respondents for black box testing may include a business owner, a manager, home owners or anybody in the community who are 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 will be evaluated by Information and Communications Technology (ICT) expert 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 involves gathering data that describe events and then organizes, tabulates, depicts, and describes the data collection [13]. 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 involves the choice of subjects who are 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 [14].

Using purposive sampling, the researcher selected 40 potential end users of the system and 15 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 is composed of five options in which the respondents can use to rate the acceptability and functionality of the system's output. This questionnaire is based on ISO/IEC 205010:2011. To rate the conformance of the system based on ISO 25010 a five rating scale with corresponding description is used as follows: Excellent(5), Very Satisfactory (4), Satisfactory (3), Good (2) and Poor(1).

RESULTS 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 Automated Misting System

Characteristics	End Users		IT Experts		Entire Group	
	M	VD	M	VD	M	VD
Functional Suitability	4.94	E	4.9	E	4.92	E
Performance Efficiency	4.75	E	4.77	E	4.76	E
Compatibility	4.88	E	4.80	E	4.84	E
Usability	4.69	E	4.70	E	4.70	E
Reliability	4.77	E	4.73	E	4.75	E
Security	4.72	E	4.66	E	4.69	E
Maintainability	4.73	E	4.88	E	4.80	E
Portability	4.75	E	4.77	E	4.76	E
Weighted Mean:	**4.78**	**E**	**4.77**	**E**	**4.78**	**E**

**E – Excellent; VD- Verbal Description*

The result of the evaluation of the Automated 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 4.78 (Excellent), for the It experts is 4.77 (Very Satisfactory) and a mean rating of 4.78 (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 [15] 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 4.94 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 facilitate the accomplishment of specified task and objectives. This excellent by the IT experts and mean rating of 4.92 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 4.75 which is excellent, the IT experts has given the highest rating of 4.77 which is also excellent and a mean rating of 4.76 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 4.80 also excellent and 4.84 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 [16] stating that systems compatibility is related to the issue on system integration. The various system's 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 4.70 though lower but still very satisfactory and an over-all rating of 4.70 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 [17] 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 4.75 mean rating as a whole, which is excellent. The end users rated it with 4.77, which is excellent while IT experts gave a mean rating of 4.73 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 4.69 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 4.72, which is excellent, while the IT experts gave a rating of 4.66 which is excellent. The results only shows 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 [18] 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 4.73, while the IT expert rated it with 4.88, also excellent. This makes the over-all rating of f 4.80, 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 4.76, which is excellent as a whole. The end users viewed the system's portability as excellent with a mean rating of 4.75 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 [19] 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.

CONCLUSION 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 misting system; make the system operate automatically based on the humidity and temperature of the area and create a system operations log. 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. Furthermore, the system makes industrial or warehouse management better as the system lessens workplace hazards caused by changes in temperature and humidity.

The researcher recommended to future researchers to make use of wireless sensors for humidity, temperature and tank level detection in the designed and development of misting system. 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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