Agricultural Crop Monitoring Using Online 3D Visualization Technique

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Abstract- Technologies have greatly shaped the activities in farming. In this context, agricultural information technology has brought about significant change in agriculture development, especially the adoption of technological tools in agriculture farming, including the 3D visualization technique in agricultural crop monitoring applications. Hence, a farmer must make timely decisions to make most from scarce resources, and thus, timely and appropriate information to allocate use of scarce resources efficiently and economically for production is essentially important towards high productivity and maximum profitability. In other words, monitoring crop or plantation can help farmers assess the real nature of the problems and analyze various alternatives in the deciding-making processes like what to produce and how to produce as well as providing a strong structure for decision-making when issues arise. Although farm management are known to be important, key issues related to good management practices which can enhance production efficiency still need to be addressed. Therefore, good crop or plantation monitoring is vital for the development of agrarian technology. Good agricultural crop monitoring also rests upon the ability to make right decisions. But there is no study has explored such monitoring decision system especially for monitoring plantation. This also is a motivated significance behind the present study.

Keywords— Online, 3D visualization, Agriculture, Crop, Monitoring

I. Introduction

In modern agriculture, farmers are also the managers of their businesses. For farmers to optimize agricultural production they must be highly competitive; as the manager of the enterprise, they are expected to bring about maximum profit. For that reason, farmers usually perform many management functions to achieve maximum production such as: giving clear instructions, deciding on the best possible action at the right time, and implementing the chosen solution.

Hence, a farmer must make timely decisions to make most from scarce resources, and thus, timely and appropriate information to allocate use of scarce resources efficiently and economically for production is essentially important towards high productivity and maximum profitability. In other words, monitoring crop or plantation can help farmers assess the real nature of the problems and analyze various alternatives in the deciding-making processes like what to produce and how to produce as well as providing a strong structure for decision-making when issues arise. Although farm management are known to be important, key issues related to good management practices which can enhance production efficiency still need to be addressed. Hence, research on how to improve plantation monitoring practices is still ongoing [3]. Therefore, good crop or plantation monitoring is vital for the development of agrarian technology. Good agricultural crop monitoring also rests upon the ability to make right decisions.

Moreover, literature on smart agriculture found that the combination of internet technologies and the adaptation of technological-based monitoring practices will play a vital role towards reframing strategies to boost the cultivation of increasing farm productivity while providing remunerative returns for farm families. But there is no study has explored such monitoring decision system especially for monitoring plantation. This also is a motivated significance behind the present study.

Henceforth, the motivation behind this study is to demonstrate that the adoption of smart technologies such as data-driven decision-making system is the best solution to a better, more efficient and timely decisions [4]. Therefore, another significant motivation for this study is to develop a more rigorous approach to solving growers' problems through a technology dependent system particularly for the monitoring of plantations. Hence, the critical need to focus on an efficient and productive monitoring system such as online 3D visualization system.

Furthermore, new technology is revolutionizing modern farming. In these light, smart farming technologies such as the 3D visualization system is widely used in the operations of most agriculture fields today [6]. In this context, the visualization of existing and future agricultural plantation is becoming more important for monitoring crops as well as for decision-making, as it considerably helps to influences the production. The concept of best monitoring plantation is an important stage of agricultural technology development; for instance, utilizing online 3D visualization system to support monitoring processes [5]. Along these lines, [8] had explored the implementation of online 3D terrain visualization technique. Unfortunately, the system concentrated on 2D visualization and was not implemented in 3D visualization.

Naturally, the vast plantation information i.e. the tree and its associated spatial information from plantation is 3D, and, in this way, the online 3D visualization system is an essential prerequisite set for this research. Moreover, this study aims to investigate the issues related to the monitoring of agricultural plantation crop (dragon) and to determine solutions to address facts concerning designing a system namely online 3D visualization technique in monitoring plantation. On that account, the present study is designed to show that the adoption of online 3D visualization system is important to ensure effective plantation crop monitoring.

II. KEY ISSUES IN ONLINE 3D VISUALIZATION

Graphs are found in various applications, for example, web surfing, state–transition outlines, and information structures. Generally, graph consists of objects (images) or entities (Beck et al., 2017). In the context of this study, graphs mean 3D graph of visual plant. Plant visualization is based on virtual organ and 3D graph of visual plant is rendered by 3D engine which read the attributes of virtual organs to control the rendering process [7]. [1] described any data that has picture view can be modeled as a graph such as, animal, species, trees, computer file systems, and so on. Unfortunately, there are size limitations and multi-sided quality of structures in 2D visualization. On the contrary, multidimensional graphs can be easily visualized in 3D and the possibility of movements in 3D space.

This study examines the basic visualization of farm in 3D form. The outcome of this research will enable farmers or plantation managers to view their plantation estate in virtual online 3D condition. Each of the virtual tree is visualized in 3D space so that they can be seen as natural plants. That means the 3D visualization of plantation generates 3D objects for each of the dragon trees. The total size of the graph will be large when the number of trees in the plantation increases. Unfortunately, memory is limited in storing capacity and cannot hold an infinite amount of data. For this reason, many visualization systems do not support the large data sets [3]. In a first step, terrain data is loaded from the terrain setup, and temporary storage is created to hold the server data. This part stored the retrieved data into temporary storage, which is the window registry (limited to 1Mb of data). The created memory holds a tree position and tree information. Large size or large-scale graphs can affect on limited memory size that should be addressed. The relative visibility will drop with ever-growing size of graphs visualization.

III. RESEARCH METHODS

This section contains about the step by step process that are conducted the research. Design research methodology is chosen; due to the main goal of this study is artifact, which is framework. It includes the framework of the study and other contributing factors in this research study. In summary, it consists of five parts (1) awareness of problem, (2) suggestion, (3) development, (4) evaluation and (5) conclusion. Each of phases has its own activities with outcomes and achieved the research objectives.

1) Plan of action:

The implementation of the project will be started from July, 2020. Figure 1 showing the flowchart of research activities as below:

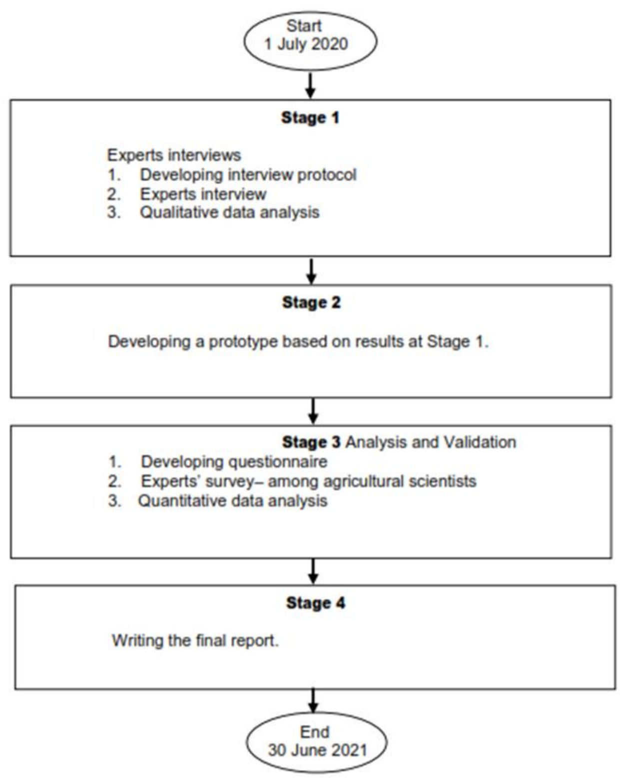

Figure 1: Flowchart of research Activities

This research study can be divided into three distinctive stages:-

Stage 1 :

In this stage, expert's interviews being conducted. It involves the experts in online 3D visualization from academia, practitioners and private company representatives. On the other hand, experts in dragon plantation management also being interviewed. It was targeted experts involved between 6 to 12 people. This method

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was employed to identify the potential factors of online 3D visualization techniques for dragon plantation.

Figure-2. The field visit results from the study area

Stage 2:

In this stage a prototype of online 3D visualization technique for dragon plantation based on the results from Stage 1 have been developed. This section covers the methodological steps that is used for design and developing a new conceptual framework of online 3D visualization technique for agriculture crop monitoring. At the end of the previous stage (suggestions phase), chapter 3 explains the methodological approaches, process, and techniques used to achieve the objective 2. The previous literature helped identify and recognize the methodology used to develop online 3D visualization framework in this section. Based on the literature review, expert' consultation, interview, observations and the empirical case studies are examined to demonstrate and development of the proposed framework. The results of the preliminary study also used to develop the proposed framework. This chapter encompasses the implementation phase from the design science research to validate the new framework through prototype development to formulate objective 3. This prototype of the application is a proof of the concept that demonstrated in this section that is much more effective process of requirements validation.

In this regard, [5] stated in their research built a web-based farm information system using 3D visualization technology. Their research, entitled "a web-based 3D farm information system for enhanced information dissemination" examined how to disseminate information to farmers through 3D visualization technology. Their research focused on three

layers and showed plant information through 3D visualization to empower farmers to make better decisions for crop yields. Their research focused on 3-layers architecture and showed plant information through 3D visualization aimed to improve the way information disseminates to farmers. They showed that their area of the plantation will be view virtually. That means the 3D visualization of plantation will generates 3D virtual objects for each of the trees. The total size for the 3D virtual objects or 3D graphs will be large when the number of trees in the plantation increases. Unfortunately, there is no directions for managing such large size graphs as memory is limited in storing capacity and cannot hold an infinite amount of data. Even though, when the scale of volume increases, the visibility, usability, and discernibility of graph visualization relatively will drop. For this reason, many visualization systems do not support the large data sets. That is very important to take in considerations to view their plantation estate in virtual online 3D condition. Hence, this study proposes to enhanced this existing 3-layer architecture to 4-layer architecture thereby allowing online 3D visualization problem. [12] posited that the web could show land data in rich structures and offered easy to use interfaces. One of the promising patterns in current GIS is the utilization of Web 3D innovation. Figure 3. Shows the architecture of this framework.

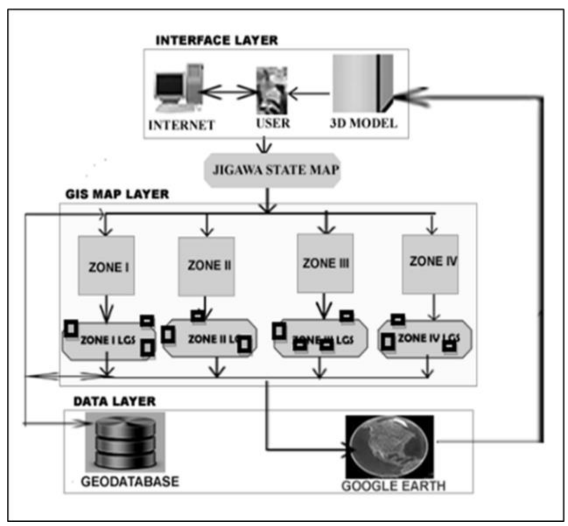

Figure 3. Architecture of Web-based Farm Information (Source: Obiniyi & Abubakar, 2015)

Tree Modeling

In this function, the tree is modeled by using 3D modeling software. Besides this, the tree is colored as green to make the tree presence more viewable inside the prototype. The dragon plantation is modeled where the tree is entirely modeled with the textured image using the polygon. This tree modeling is also virtually incorporated into the visualization process layer.

Figure-4: 3D model of Dragon tree

Stage 3:

This stage involved survey among dragon cultivars to analyse and validate the prototype to be developed. Questionnaires containing dimensions related to the prototype will be asked to the selected dragon plantation scientists around Gazipur district. The number of respondents was 20. Collected data being analyzed with the help of IBM SPSS version 23 computer package program. This study employs a questionnaire as the main evaluation instrument to investigate whether the prototype is effective and workable in terms of usability. Generally, Oppenheim (2000) has described the questionnaire as a widely used research instrument that is reliable in terms of data collection. Throughout the review process, two mediums of communication were used email review and face to face review. Hence, to design the evaluation instrument, a systematic approach was adopted in which the rigor process of instrument development.

IV. RESULTS, DISCUSSION AND CONCLUSIONS

The final chapter in this thesis draws together the results in the previous chapters, discussed these findings, highlights the future directions that online 3D visualization research for plantation monitoring has taken in and provided the conclusions on the research performed. In summary, the discussion on how to develop, implement, analyses and validate a new framework of online applications of 3D visualization has been presented. and finally, concludes the research.

Finally, this section deliberates on the findings of this study by answering all the research questions and research objectives. Besides, it discusses the contributions of the study to the body of knowledge, as well as highlighting recommendations for future directions of the study.

The final results is reported based upon the results of analyses and the expected study findings in narrative form. The findings of the study can be represented in a graphical or non-graphical form where research objectives are additionally clarified. A summary of the study, conclusions are drawn from the findings and an evaluation discussion of the developed

Figure-5. Interview with farmer

Several interviews and expanded discussions with farmers and experts have been carried out.

At the end of this part four (development phase of DSRM), here the final online 3D visualization prototype based on the framework was evaluated by plant cultivars and 3D visualization experts. Betides this, an empirical field study evaluation method named Trial-run is used to evaluate the prototype of this study. This chapter used questionnaires containing dimensions related to the prototype functionality. Here, a number of interviews, observations, and expanded discussions with experts have been carried out to review the developed system framework and prototype. Therefore, this chapter is to evaluate the prototype results and the results of the evaluation indicate that the system achieved their satisfaction or efficient in ease of use by allowing growers to solve crop monitoring problem. The results of the usability evaluation indicated that the system achieved its satisfaction or efficient in ease of use.

prototype especially as for the original purposes and hypothesis of the study was exhibited. The final report section also includes validation reports related to the research questions being answered. Inside this last report segment, the researcher attempts to translate findings and conclusions and relate these to both the motivation behind the investigation. Final reports reflect clear, brief, and composed for a broad scientific audience. Finally, a detailed description of recommendations for the future study based on the significance of findings is drown.

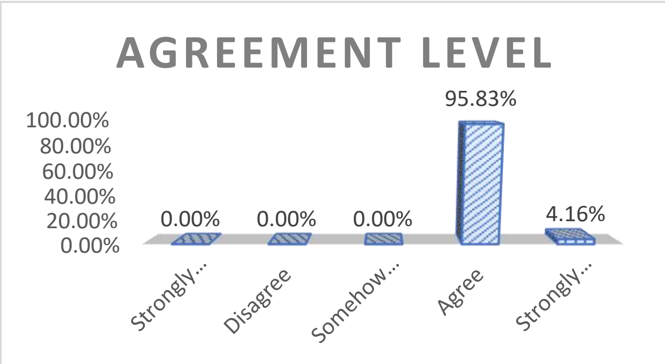

Figure-6. Level of users' agreement

Overall, results from the usability testing demonstrated that it can comfortably support or handle monitoring information of the plantation, and thus formulating the research issue; it is also proven that the results of enhanced architecture achieved its satisfaction through solving visualization problem.

Appendix

Appendixes, if needed, appear before the acknowledgment.

Acknowledgment

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