

# **An Automated Real-Time Monitoring System for the Study of Seeds Biology**

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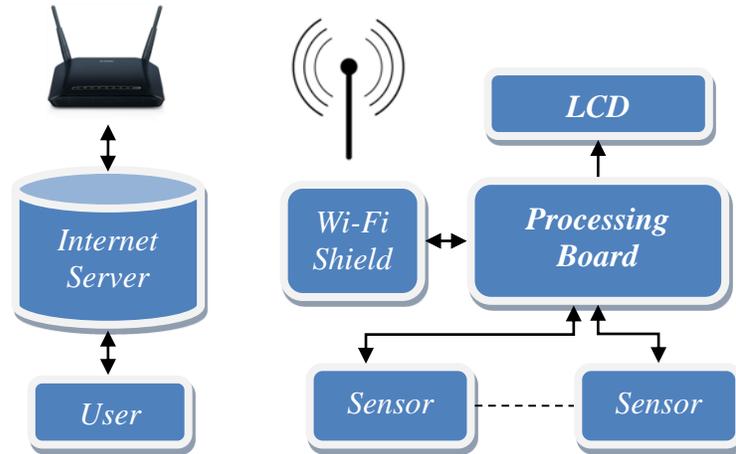
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## **Abstract**

The current research describes the design of a real-time remote monitoring system that is used to study seeds biology under various controlled conditions. The research will help biologists in determining the optimal conditions for after-ripening in seeds, which are necessary for successful seed storage and germination. Seed biology is an important part of plant science. Many seed germination experiments are carried out under controlled environmental conditions in closed containers that are placed in controlled incubators. Seeds scientists have experienced various difficulties and uncertainties in monitoring and maintaining various parameters inside the closed containers such as temperature and relative humidity. The common practice amongst biologists is the use of super-saturated solutions of different chemicals to provide relative humidity measurements. However, these super-saturated solutions may not be accurate enough and require continuous (manual) checking by the researchers. The current paper describes the design and development of a remote monitoring system that can be used to accurately measure and monitor the temperature and relative humidity inside closed containers that are used for the study of after-ripening in seeds. What makes this task especially challenging is that the closed containers are normally housed in an incubator that maintains the desired temperature. The incubator is not permeable to most electromagnetic signals required for the wireless communication with the monitoring system.

The system under discussion allows the monitoring of the temperature and relative humidity of several (five in this case but can be expandable to more if needed) closed containers remotely and in real time. The system functions as a server that is connected to the Internet using Wi-Fi. When a client requests data, the system reads the sensors' values and passes them wirelessly to the client. In addition, the client is able to see the data remotely from any place using a web browser and is able to plot, manipulate, and study the data almost immediately. A time and date stamp is provided with each measurement. Application-specific software is created to implement data logging and facilitate data transfer into Microsoft Excel for further analysis.

The system uses multiple sensors, a microcontroller, and a Wi-Fi module. Figure 1 illustrates the basic block diagram of the system. The full paper will provide complete details of the system and results. The research is being performed through collaborative efforts between the Engineering Technology and Biology Departments at Middle Tennessee State University.



**Figure 1. Real-Time Remote Monitoring System for the Study of Seeds Biology.**

## Biographies

Dr. Saleh M. Sbenaty is currently a professor of engineering technology at Middle Tennessee State University. He received the B.S. degree in E.E. from Damascus University and the M.S. and Ph.D. degrees in E.E. from Tennessee Technological University. He is actively engaged in curriculum development for technological education. He has authored and co-authored several industry-based case studies. He is also conducting research in the area of mass spectrometry, power electronics, lasers, instrumentation, digital forensics, and microcontroller applications. Dr. Sbenaty can be reached at [Saleh.Sbenaty@mtsu.edu](mailto:Saleh.Sbenaty@mtsu.edu)

Mr. Thiruparan Balachandran is an Embedded System Engineer employed at Proteus Digital Health Inc. Digital medicine is the primary focus of his company. Mr. Balachandran received the Master's degree in Engineering Technology from Middle Tennessee State University and the BS degree in Engineering Physics. He is interested in embedded system, especially the wearable wellness and medical devices. He has published several conference papers and can be reached at [tbalachandran@proteusdh.com](mailto:tbalachandran@proteusdh.com)

Dr. Jeffrey Walck is a Professor of Biology at Middle Tennessee State University. His research interests focus on the ecology of seed germination and on the conservation biology of the cedar glade ecosystem. He has been an Invited Visiting Scientist to Australia, Japan, South Korea, Taiwan, and China. Dr. Walck can be reached at [Jeffrey.Walck@mtsu.edu](mailto:Jeffrey.Walck@mtsu.edu)