Integration of Asset Tracking System through Trilateration Method as Detection Mechanism

To cite this article: M A Fadzilla *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **557** 012038

IOP Conf. Series: Materials Science and Engineering **557** (2019) 012038 doi:10.1088/1757-899X/557/1/012038

Integration of Asset Tracking System through Trilateration Method as Detection Mechanism

M A Fadzilla[1, 3], Shahriman, A.B[1, 5], A. Harun[1, 3], M.S.M Hashim[1, 2], Z.M Razlan[1,2], W.K Wan[1, 2], Z. Ibrahim[5], Abdullah, A. H[2],. J.S.C Turner[1, 3] , K.A.A Kassim[4], M.S.A Khalid[4], Z. Jawi[4] and M.H.M Isa[4], R.C Ismail[3]

[1]Motorsports Technology Research Unit (MoTECH), Universiti Malaysia Perlis, Pauh Putra Campus, 02600 Arau, Perlis, Malaysia

[2]School of Mechatronic Engineering, Universiti Malaysia Perlis, Pauh Putra Campus, 02600 Arau, Perlis, Malaysia

[3]School of Microelectronic Engineering, Universiti Malaysia Perlis, Pauh Putra Campus, 02600 Arau, Perlis, Malaysia

[4]Malaysian Institute of Road Safety Research (MIROS), Lot 125-135, Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor, Malaysia

[5] Faculty of Technology, University of Sunderland, St Peter's Campus, Sunderland, SR6 0DD,United Kingdom

*Corresponding author: shahriman@unimap.edu.my

Abstract. Demands for localization system has been growing rapidly in the last several years both for an outdoor and indoor area. In conjunction with this, the capability and reliability of this system to precisely locate and track objects of interest for the indoor area has catered researchers and study on how to do so. One of the major ideas on making it more advance is by incorporating the use of wireless devices into the system. There are numbers of issues that could interrupt the efficiency and success of the system. One of the main problems is the signal loss mainly caused by the attenuation of the signal as they propagate through from the transmitter to the receiver. These attenuations are mostly due to the surface types the signal are traveling on and the objects that are in the Line of Sight in between the transmitter and receiver. In order to ensure the most reliable and efficient wireless connection between transmitter and receiver, a propagation study on the signal is needed for us to analyze and find the best way to trade off the signal attenuation based on the environment surrounding the system. By doing so, a thorough system that has models that can work efficiently even if we are to consider the attenuation factors. The system consists of nodes installed inside the research institute that acts as both transmitter and receivers. The transmitter and receiver will then process the signal that will then determine their location. The receiver is connected to the laptop in order to get a real-time reading so that we will be able to locate the transmitter. A networked of nodes are installed inside the research institute for experiment and the layout of the research is conferred for future references. Data from the experiment are then analyzed and a model for the signal propagation alongside the research institute is created. This model will be able to apprehend the signal attenuation despite the surrounding environment such as furniture and walls. A completed asset tracking system with models of signal attenuation will be built in the future for a more efficient signal transmission.

1. Introduction

Demands for localization system has been growing rapidly in the last several years for both indoor and outdoor area. Hand in hand with this, the capability and preciseness of the system to locate the objects of interest has been an important research topic and study.

Asset tracking has been a major solution for multiple localization problems in the industry and daily lives of people. The development of asset tracking system, however, has been slow for the past years due to less usage in consumers' daily lives[1]. Nevertheless, the application of asset tracking in the industry is growing rapidly especially in warehouses, logistics management, plantation or even manufacturing lines. Large companies in the industry might benefit from the system as they need to manage a huge number of company's assets and other equipment.

As an example, a shipping company requires an efficient asset tracking system to packages and handles shipments. Some other companies tracks certain types of asset such as construction vehicles, the packaging itself, scanner for identification of packages and even the smallest things such as files and documents. Management of these asset is crucial as the assets are movable and will be brought out by workers as they transfer the packages from one location to another. Considering that human errors such as misplacing of scanners and misplacing of packages this will lead to a huge localization task as they need to track and find out the missing asset by themselves without knowing where they are. Hence to reduce the time-consuming method of finding the items manually, asset tracking system meant to reduce tracking time and also increase the efficiency of the company. This paper focuses on designing an asset tracking system to locate indoor assets or items.

Trilateration is a method that is alternative to that of a triangulation that relies on the distance measurements only. Electronic devices distance measurement makes trilateration a cost-efficient localization technique for control surveys[2]. It can also be used to determine the location coordinate and location by using both the transmitter and receiver. It has the same working concept as that of triangulation[3].

Multiple nodes will be placed inside a location of interest to create a network that will then be analyzed to locate a moving node that is inside or within the reach of the nodes. The same concept was used in Global Positioning System (GPS) localization considering that the nodes placed acts as a satellite while the moving nodes are the object of interest that is to be located[4].

For indoor areas, developments and advancements have emerged from researchers by building a system that can precisely locate and track an object of interest on a real-time basis. Indoor area has been more variegated in terms of application due to the fact that the typical GPS would not be able to be used in an indoor area due to its limitation[5]. This has brought upon the idea of implementation of radio technologies and also the application of IEEE 802.11 (Wi-Fi)[6]. However, rather than being a hassle, this is a huge advantage for developers and also researchers due to the fact that the technology is common and widespread making it easier and more flexible to be adjusted and improvised[7].

2. Materials and Method

2.1. Equipment

The system consists of multiple nodes placed inside our research institute for monitoring of either moving or stationary objects. The system was carried out by using a pair of transmitter and receiver of XBEE S2 nodes from Digi which will be represented as nodes. These nodes operate at 2.4 GHz and antennas with gain of 2 dBi omnidirectional [8]. Both transmitter and receiver were mounted at 0.8 m height above ground. The real reason for allocation of height is such that on average the height of furniture inside the research institute is at 0.8 m. By doing so, we will be able to perform a functional asset tracking system with consideration of furniture and walls as obstacles and eliminates the possibility of the signal attenuation due to the floor surface by placing it at 0.8 m above ground.

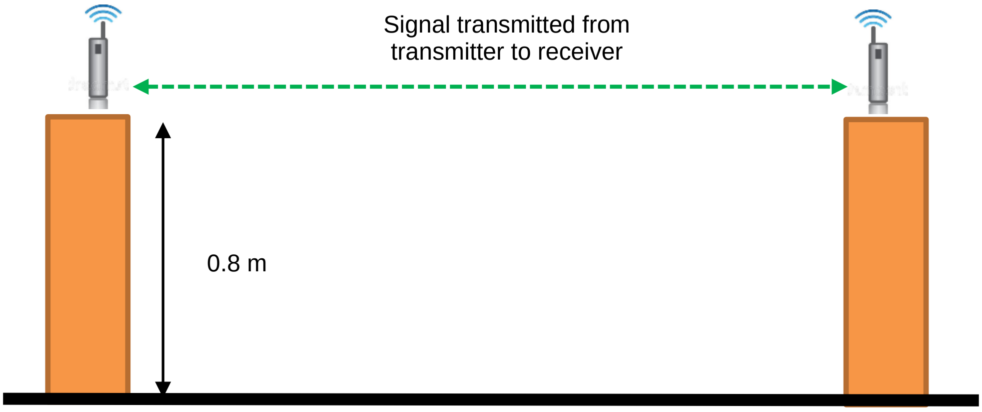

Figure 1. Nodes placement and height.

For the receiver, it will be connected to a laptop that will display the current location of the nodes placed inside the research institute and also the location of the moving node whenever the user requested it. As shown in Figure 1, the transmitter stated as Tx was mounted on a mobile object that will be moving around the research institute. Meanwhile, another set of nodes consisting of 4 XBEEs will then be attached to a stand that represented as receiver, Rx which will be stationary. The receivers will be connected to a transmitter and keep on receiving signals from the transmitter as long as it is powered up.

2.2. System Setup

For this system, signal strength is implemented to indicate the received power when carrying out the pilot test. Accordingly, a Received Signal Strength Indicator (RSSI) can be predicted and measured based on the average signal strength over the distance of radius centered on the receiver[1]. During the whole experiment, the furniture allocation and placement are kept fixed as shown in Figure 2. Meanwhile, the number of people inside the research institute during the experiment were kept fixed and minimum as only the person in charge of reading the signal strength and another one as the person allocated to moving the transmitter inside the research institute

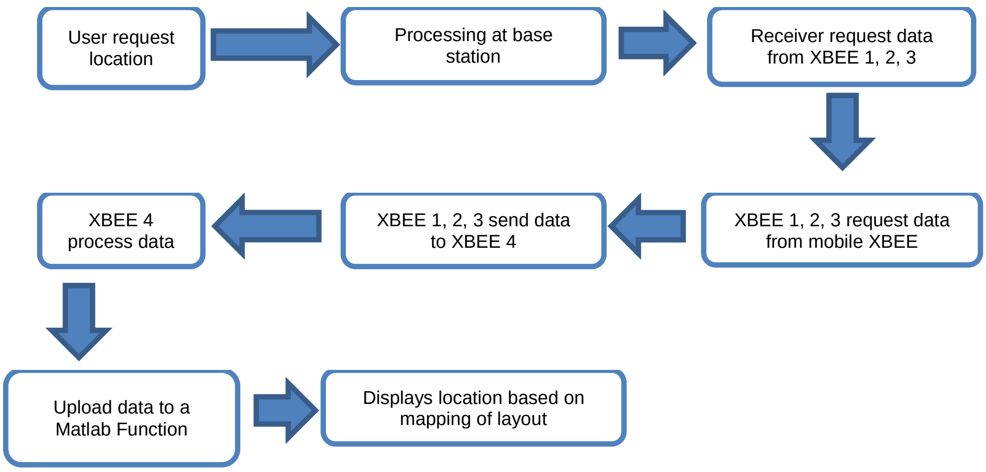

Figure 2. Flow chart showing the process designed for the system to collect and transmit data.

IOP Conf. Series: Materials Science and Engineering **557** (2019) 012038 doi:10.1088/1757-899X/557/1/012038

For the indoor localization system, a mesh network was designed in order to perform a localization system application for the experiment. XBEE 1, 2, 3 are receivers that are connected to both the receiver and base station, while XBEE4 is a transmitter which only connects to the receiver at the base stations. Mobile XBEE only connects to XBEE1, 2 and 3. Whenever the user request for the location of the tagged item, XBEE 4 will send a request to all receivers to feed XBEE4 the current RSSI of the mobile XBEE in order to determine its current position. The mesh network design can be seen in Figure 3.

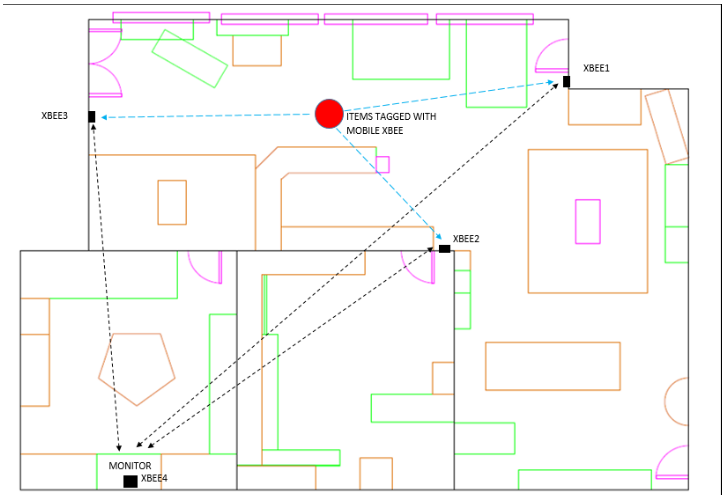

Figure 3. Mesh Network Design.

From this design, we can expect that whenever the user request, the current location of mobile XBee can be shown and located on the monitor that is connected to the XBEE 4. For the localization system experiment, the mobile XBee will be carried along by a human to stroll out along the research institute and then set to appear on a real-time basis

3. Results and Discussion

For the indoor localization system, a signal propagation was studied and analyzed based on a previous study [9], [10]. The properties of signal that propagates inside the research institute were analyzed and studied to create a model that will then ensure an effective and efficient signal transmission inside the research institute. Theoretically, the complexity of the environment causes the fluctuations in the signal power while the objects surrounding its path influence the signal strength [11]. However in real time application, this might not apply as every room or indoor area are different according to its purposes such as warehouse, offices, pantries and leisure room. Each of these rooms possesses its own purpose with its own furniture and equipment. Hence a proper signal propagation study is needed beforehand[12].

From the propagation study intended before, we have come out with a layout of the research institute with specific measurements as the intended distances needed for trilateration method can be clarified either the distance measured and predicted by the system is the same as that of the real measurements. This is compulsory as we will be able to identify the major factors affecting the signal propagation as the signal is transmitted from a transmitter to a receiver.

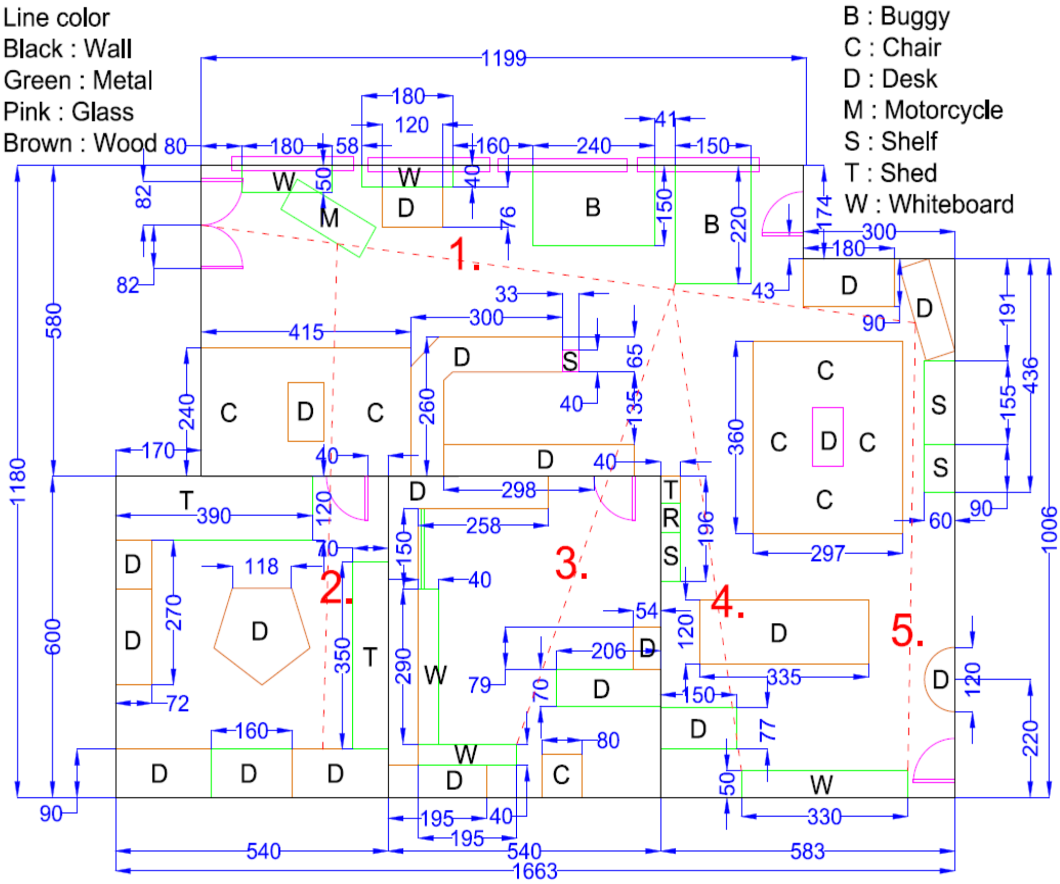

Figure 4. Layout of the Research Institute.

For the localization system, however, we need to be able to identify the major signal attenuating factor that will need to be considered in determining the proper propagation study on the signal. These factors are mainly known as a propagation mechanism. Propagation mechanism of the signal transmitted refers to how the signal is being propagated. Scattering, reflection, and diffraction are the most common mechanism that encountered in a typical signal transmission[13][12]. Scattering occurs when the transmitted signal is faced with large numbers of small dimension objects like that of metal cabinets, lampposts. The reflected energy during the scattering process is spread out in multiple directions before reaching the receiver[6]. This shows that the signal power transmission does not efficiently happen even though the signal is received in the end. For reflection, it happens whenever the transmitted signal encounters an object with large dimensions as compared to its wavelengths such as walls, ceilings, and sofas[10]. Some of the signals that have been transmitted will be absorbed through these medium and the remaining will be reflected off of the medium's surface [14]. While diffraction occurs whenever there are obstacles or objects that have sharp edges resulting in a secondary signal that in effect bend around the obstruction [6]. In normal situations, these aspects need to be taken into consideration whenever analyzation of signal propagation is performed.

IOP Conf. Series: Materials Science and Engineering **557** (2019) 012038 doi:10.1088/1757-899X/557/1/012038

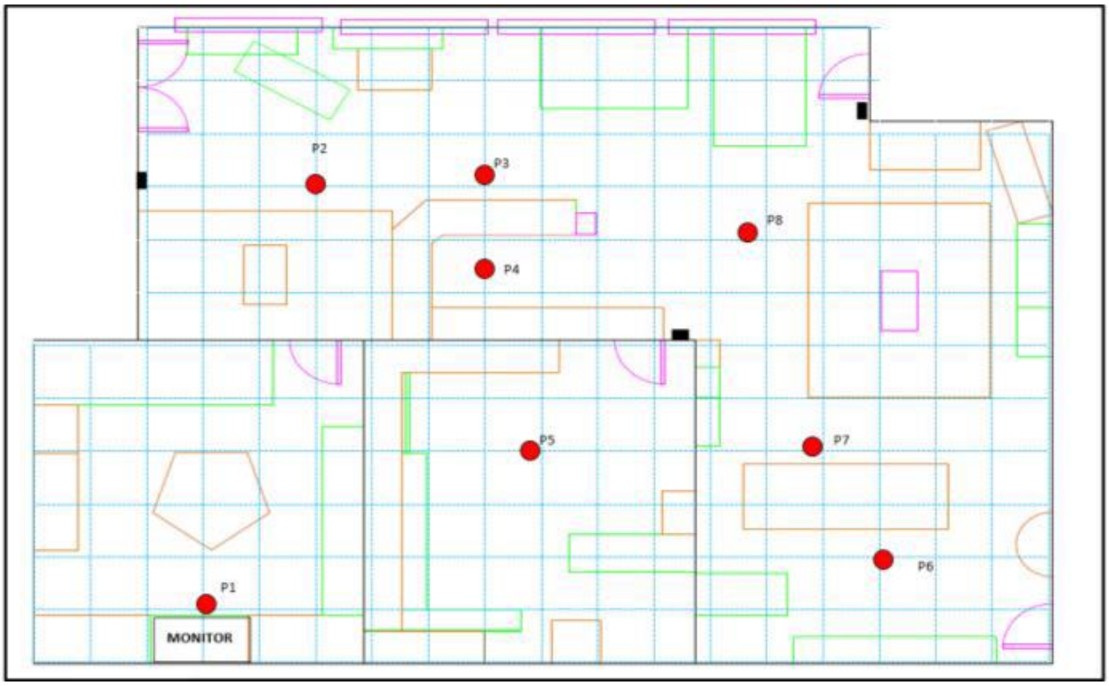

Figure 5. Simulation by using Matlab for 8 XBEEs for indoor localization system.

The indoor localization system was executed by using 8 different receivers with the same settings while being at different positions. The user requested for the monitoring module to display all 8 location of tagged items at the same time and display it at the monitor. The result can be seen as shown in Figure 5. It is observed that the localization of the tagged items was almost accurate with an error of up to 2 meters. This shows that the indoor localization system can be performed by using XBEE. This, however, does not mean that XBEE is the best option in implementing the most efficient indoor localization system. However, in terms of performance, the signal propagation does not perform well based on the signal profiling done in my previous paper. This is mainly due to the interference of furniture, walls and the surface of the floor.

For each of the localization intended for each points starting from point P1 to point P8, there is some attenuation in the measurements of the distance they are away from the XBEE 1, 2 and 3. This may be due to the positioning of the furniture. For example for point P6, the distance predicted by the system was that they are to be 14.2 m away from XBEE 1 meanwhile the actual measurement is that they are 12.7 m away from XBEE 1. This has confirmed us that the system still has an error in the prediction of location for up to 2 m. This shows that the system still has flaws in them in terms of prediction of distance. This has allocated us some major improvisation on the system accuracy and also prediction ability. This can be handled more efficiently by making a more subjugated study and more specific modeling in future system development.

A more subjugated and variegated system design is still needed in order for us to perform the best and most efficient asset tracking system. This is a need in order to ensure the highest accuracy in the system and also the best in terms of robustness, and complexity of the design itself. Other than that, we may need to consider other wireless devices such as LoRa, MEMSIC, and WLAN.

4. Conclusion

This paper presented an integrated wireless asset tracking system designed to locate and track desired asset or objects around area of interest in this case the indoor area of our research institute. The design was done in consideration of the furniture, walls and also the layout of the research institute in order to minimize the signal attenuation caused by the obstacles and also minimize the signal loss making it more reliable and accurate. This paper however looked into only the application of wireless asset tracking for indoor area only.

Based on the preliminary data collection on controlled surrounding, it is observed that the localization of the tagged items was almost accurate with an error of up to 2 meters. This shows that the indoor localization system can be performed by using XBEE. This, however, does not mean that XBEE is the best option in implementing the most efficient indoor localization system. However, in terms of performance, the signal propagation does not perform well based on the signal profiling done in my previous paper. This is mainly due to the interference of furniture, walls and the surface of the floor. Further improvements and studies are needed for us to design a better and more reliable wireless asset tracking system in the future.

Acknowledgments
The authors would like to acknowledge Eastern Pacific Industrial Corporation Berhad (EPIC) for financial and administrative support on this project through the academic-industry collaboration programme.

References

[1] S. Shukri *et al.*, "Analysis of RSSI-based DFL for human detection in indoor environment using IRIS mote," *2016 3rd Int. Conf. Electron. Des. ICED 2016*, no. August 2016, pp. 216–221, 2017.

[2] "11. Trilateration | The Nature of Geographic Information." [Online]. Available: https://www.e-education.psu.edu/natureofgeoinfo/c5_p12.html. [Accessed: 08-Jan-2019].

[3] S. S. LATHIKUMARI, "WALAN INDOOR BASED LOCALIZATION," UNIVERSITY OF TEXAS, 2011.

[4] P. Sedlacek, M. Slanina, and D. Kovac, "An Overview of Indoor and Outdoor Positioning Technologies with Focus on their Precision - An Overview of Indoor and Outdoor Positioning Technologies with Focus on their Precision," 2016.

[5] A. A. Khudhair, S. Q. Jabbar, M. Q. Sulttan, and D. Wang, "Wireless indoor localization systems and techniques: Survey and comparative study," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 3, no. 2, pp. 392–409, 2016.

[6] A. H. Ali, M. R. A. Razak, M. Hidayab, S. A. Azman, M. Z. M. Jasmin, and M. A. Zainol, "Investigation of indoor WIFI radio signal propagation," *ISIEA 2010 - 2010 IEEE Symp. Ind. Electron. Appl.*, no. Isiea, pp. 117–119, 2010.

[7] J. S. C. Turner *et al.*, "Modelling indoor propagation for WSN deployment in smart building," *2014 2nd Int. Conf. Electron. Des. ICED 2014*, pp. 398–402, 2011.

[8] MaxStream, "XBee ™ / XBee-PRO ™ OEM RF Modules," *MaxStream*, no. 801, pp. 1–33, 2005.

[9] I. Ibrahim, M. K. Faizi, M. A. M. Saad, Z. Ibrahim, and N. A. M. A. Hambali, "Wireless signal propagation study in an experiment building for optimized wireless asset tracking system development .," pp. 1–5.

[10] I. Ibrahim, M. K. Faizi, M. A. M. Saad, Z. Ibrahim, and N. A. M. A. Hambali, "Localization assessment for asset tracking deployment by comparing an indoor localization system with a possible outdoor localization system," pp. 1–6.

[11] W. Rong-Hou, L. Yang-Han, T. Hsien-Wei, J. Yih-Guang, and C. Ming-Hsueh, "Study of characteristics of RSSI signal," *Proc. IEEE Int. Conf. Ind. Technol.*, pp. 3–5, 2008.

[12] D. L. Ndzi *et al.*, "Signal propagation analysis for low data rate wireless sensor network applications in sport grounds and on roads," *Prog. Electromagn. Res.*, vol. 125, no. November 2011, pp. 1–19, 2012.

[13] D. L. Ndzi *et al.*, "Wireless sensor network coverage measurement and planning in mixed crop farming," *Comput. Electron. Agric.*, vol. 105, pp. 83–94, 2014.

[14] A. Asmussen, R. Rodriguez, and L. Roshak, "MC1319x Range Performance," *Free. Appl. note AN2902*, pp. 1–14, 2004.