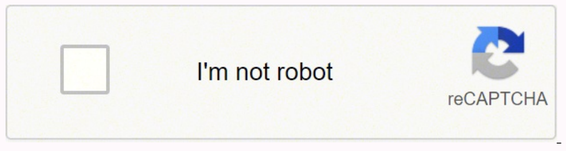

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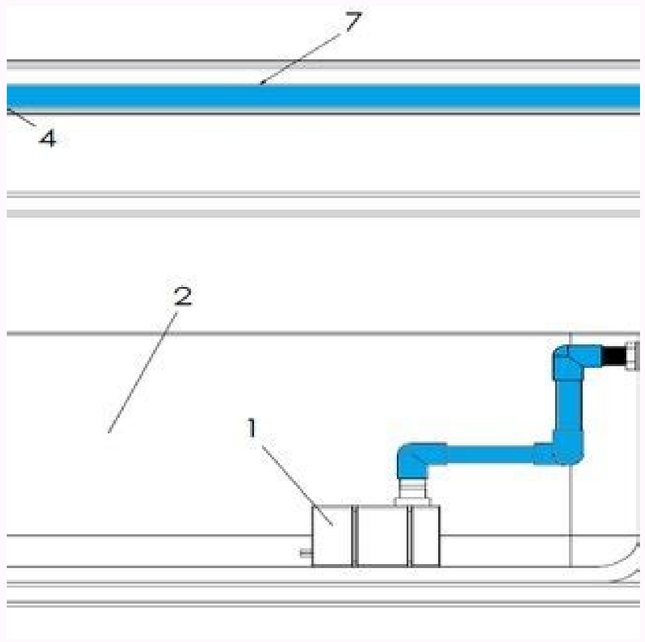

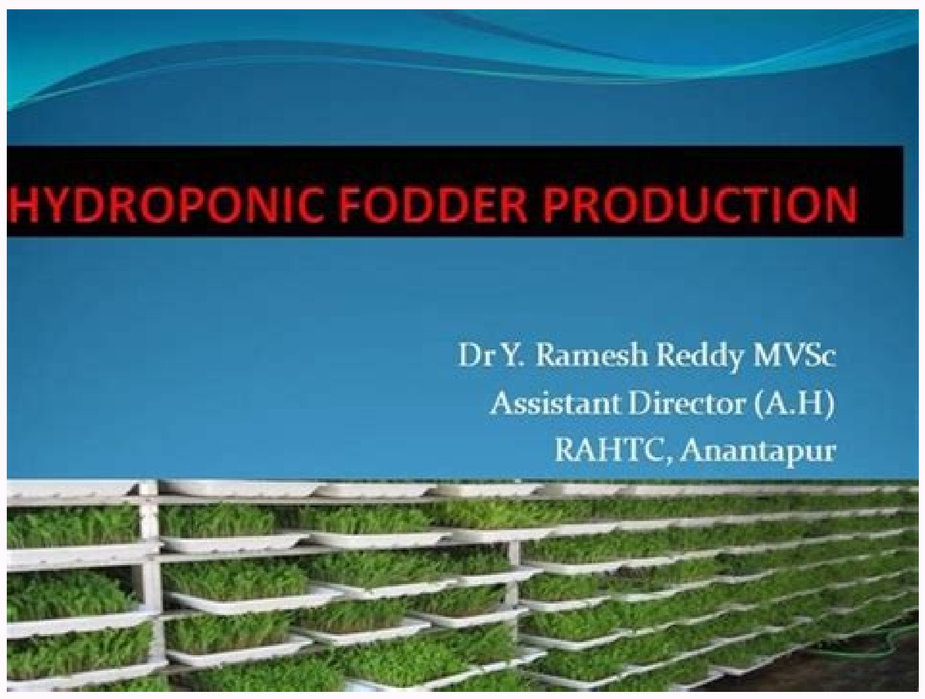

Instruction Manual
PCM3

Instruction Manual for
PCM3 Measurement Device
(Original Instruction Manual – German)

Software Revision No. 5.6

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SHORT COMMUNICATION

Variations in Round-the-Year Fodder Production in a Low-Cost Hydroponic Shed

Keshab K. Mohapatra[1] · Shibani Mohapatra[2] · Ranjit Ekka[1] · Ramesh C. Behera[1] · Ranjan K. Mohanta[2]

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Abstract The objective of this study was to evaluate four forage crops, i.e. maize, wheat, cowpea and rice bean, for green fodder production under a low-cost hydroponic shed. The experiment was conducted under temperature-controlled condition, irrigation by micro-sprinkler and closed chamber by green agro-shed net cover. The result showed that green forage can be produced in 8 days from planting to harvesting using hydroponic technology. On overall basis, maize produced the highest quantity of green fodder per kg seed (8.40 kg) round the year, followed by wheat (7.11 kg), rice bean (6.75 kg) and cowpea (6.58 kg). The yield from maize and cowpea did not vary significantly with season, whereas wheat gave better yield during Rabi and rice bean during Kharif and summer.

Keywords Cereal · Dairy · Fodder · Hydroponics · Legume · Season

Green fodder plays an important role in feeding of dairy animals. It helps in optimization of production and reproduction performance by supplying the essential nutrients and provides bulk for effective digestion and also for gastro-intestinal tract motility [1]. It also helps in decreasing the cost of production by replacing a part of the concentrate in animal feeding. The conventional fodder production practice is not widely adopted in many regions due to the requirement of large area of land per animal for cultivation, need of manure, fertilizer, and irrigation facility, pest and disease problem, intensive manpower requirement with a long growth time (45–60 days) along with non-availability of same quality green fodder round the year [2].

Hydroponic fodder is produced in greenhouses under controlled environmental conditions without soil. It can be done in a less space using limited amount of water and electricity along with marginal labour involvement [3, 4]. It also does not require fertilizers and pesticides, and the growth period is very less (7–10 days). In this practice, different seasonal fodder crops (both cereals and legumes) can be grown round the year. Besides the nutritional quality of the hydroponic green fodders is found to be better as compared to that of the conventional green fodder production [4, 5]. Hydroponic fodders are more palatable than the conventional fodders due to the difference in water and fibre content [4].

Even if there is an initial cost of installation of the structure, it can be sustainable. Keeping these facts in view, this study was designed to construct a low-cost hydroponic shed along with the provision of round-the-year fodder production and their seasonal variations in production of different fodders.

This study was conducted at the fodder wing of the Office of Chief District Veterinary Officer, Cuttack, for three consecutive years from 2013–2014 to 2015–2016 to establish this novel idea for the first time in the state of Odisha. The greenhouse was build up using locally available bamboo structure covered with agro-shed net and sides with three-rack system (Fig. 1). Provision of 60 kitchen trays was made for growing fodder in 8-day cycle and a micro-sprinkler system for giving regular and uniform irrigation. The cost of production and unit cost are

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On the other side of the structure, a second elevator, receives a tray that was pushed as consequence of the previous movement. Growing light intensity measurement was 105 µmol/m2/s therefore, the lights were turned on at least 17 h/day to fulfill plant light requirement. The system read the pH level and nutrients on the nutrient solution of hydroponics system, as well as the temperature, humidity, CO2 levels and the light intensity around the system; in addition there were LED light three lines each a different configuration on each line that was used for the lighting of plants and light color was selected and the system data were saved in SD Card.ARM cortex-M4 microcontroller (courtesy of developer arm).In addition, the system was capable to control desired concentration level with variation of less than 3%, pH sensor showed good accuracy 5.83% from pH value 3.23–10. The final position of the gripper was defined as 20 mm above the center of the cup. All parameters were taken in to consideration in order to create controlled environment exactly. The system saved water and fertilizer, but the water level in the reservoir must be checked with 2- or 3-weeks interval or water level sensor should be added to the controller circuit. solanacearumis drastically reduced by the plasma treatment and is not detected after 8 days treatment. The program started up the sensor to read data sensors, push button to read the buttons provided, mixing to perform compounding nutrients hydroponics, timer flush to set watering plants, timer lights to regulate time lighting plants by LED lights. 2016;5:63-6612. These offsets are dependent on the position of the Kinect relative to the gripper. A Microsoft Kinect camera was added to the system, which produced two kinds of images, a 640 × 480-pixel RGB color image and a 640 × 480 pixel 11-bit (0–2047) gray scale depth image that was provided by an Infra-Red (IR) sensor. The microcontroller worked in real time to setup the alarms on nutrient pumps. Calcium and iron concentration in the culture solution were significantly decreased in DC-ED, consequently their contents were also found lower in crowns and roots compared to other solutions used. The water pumps were used for water recirculation and relays used to control both nutrient solution as well drain pumps. Automation of hydroponic installations using a robot with position based visual feedback. When the seeds are placed in the tray, in the first storey near a first elevator, the next step is to elevate the tray and push it to the structure in the second storey. 1-616. 2019;19(8):176319. Water, Media and Nutrient for Green House Crops. Sheikh BA. Plant Factory: An Indoor Vertical Farming System for Efficient Quality Food Production. Yildirim M, Dardeniz A, Kaya S, Ali B. Neural network based fault detection in hydroponics. 01201710. Development of a pH control system for nutrient solution in ebb and flow hydroponic culture based on fuzzy logic. This system was simulated in Matlab SimMechanics, showing its proper operation for the mechanical and electrical parts. It was also constructed a time-based closed loop hydroponics and used a microcontroller for supplying the water to the pots (Figure 13). Hommons: Hydroponic management and monitoring system for an IOT based NFT farm using web technology. Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower. Hydroponic system design with real time OS based on ARM Cortex-M microcontroller. 2006;22:53-574. Journal of Physics: Conference Series. The position error was measured with a ruler at the final stopping position and robot then returned to the same starting position. The microcontroller switched on relaying to pumping water to the root territory only for 1 min. The initial pH of the solution was above the set point and kept on moving to reach the pH = 6. There were two buttons on the sidebar navigation. In that manner, the set point indicates that the fuzzy logic control can maintain the solution pH at the set point. In those cases, the neural network model did not encounter any difficulties predicting the rapid changes. Computers and Electronics in Agriculture. The pipeline structure consisted of six storeys and watering pumps performed system irrigation three times. Van LD, Lin YB, Wu TH, Lin YW, Peng SR, Kao LH, et al. IoT based hydroponics system using deep neural networks. IOP Publishing; 2017. In: Hydroponics—A Standard Methodology for Plant Biological Researches. A submersible pump operating at 12 DCV was installed inside the water storage tank. Ferentinos KP, Albright LD, Selman B. The core material of the PVC pipe tool with 3 in. The Kinect was placed on the carriage and is facing downwards (negative z-axis) to ensure the plants in its field of view are at a maximum distance of 1.5 m, because the accuracy of the Kinect decreases quadratically with distance. The cultivation space is optimized for the aeroponic plants are grown suspended in air, having as support PVC pipes which can be arranged horizontally or vertically, enabling a better exploitation of areas and installing a larger number of plants per square meter surface of the oven, obtaining thus a direct increase of productivity [2, 3]. Mehra M, Saxena S, Sankarana-rayanan S, Tom RJ, Veeramanikandan M. Journal of Electrostatics. RTOS ran all the tasks with a latency less than 15 µS. Environment sensor overall showed good result, temperature reading error was less than 4%, humidity reading less than 5.36% and CO2 sensor accuracy was calibrated 260 ppm from initial value. The OpenNI driver transforms the IR sensor values into distances in meters by using a fitting function. Scientia Horticulturae. If the system was turned on, the computer program turned off three pumps (stir pump, water pump and the dosing pump). Talukder MR, Asaduzzaman M, Tanaka H, Asao T. The depth information was extracted from the depth image by getting the value at point. The above advances will improve the efficiency of hydroponics to increase the quality and quantity of the produce and pose an opportunity for the growth of the hydroponics market in near future.hydroponic systemssensorsmicrocontrollersautomationneuronal networksroboticsIt is estimated that the total world population could reach 9.15 billion in 2050 [1], and to increase the global food production, even more advances in agriculture must be made intensive in crop yields and in practices that are more friendly with the environment. In this transformation, the point is the principal point in pixels of the depth sensor and the focal lengths in pixels were calculated. 2014;27(2):809-82214. The microcontroller received this voltage signal and compared it with the previous value and decided based on that input signal. The performance of the system on bacteria inactivation in the nutrient solution was evaluated in a continuous treatment system operation and the results showed that the standard plate count for background microflora and R. Some connection apparatus and valves were used in the irrigation system to integrate all items.Grapevine experimental setup.At the beginning of the test, all substrates were filled up to field capacity, then the automated system started irrigation at 4 h intervals and run the submersible pump only 1 min throughout the whole growing season so that this irrigation management kept the soil moisture at the level of field capacity in each substrate since excess water was drained to the reservoir back after each irrigation event. In addition, some Raspberry Pi 2 microcomputers served to accommodate the webserver and brokers. The model was capable of predicting pH at the next 20–min time step within 0.01 pH units and EC within 5 µS cm−1. RTOS performance was obtained using square wave input signal and measuring input signal versus output signal delay using oscilloscope. The gripper must be ±15 mm in x-direction, ±20 mm in y-direction and ±10 mm in z-direction from the center of the cup to allow the robot to pick up the plant. We thank the Universidad Autónoma de Nuevo León, Mexican Ministry of Education, as well as Mexican Council for Science and Technology for their support.1. Alexandratos N, Bruinsma J. Tanke NF, Long GA, Agrawal D, Valada A, Kantor GA. To manipulate the plants, the robot (Figure 24) was designed as a gantry with four v-groved wheels running on two inverted angle iron tracks (x-axis). In: 5th International Conference on Cyber and IT Service Management (CITSM); IEEE. Automatic sensors not only have the ones that can be read at predefined intervals, but also the readings of these sensors are stored so that higher results can be obtained for analysis and diagnosis resulting in higher crop yields and friendlier practices with the environment. The second automation page contained a selection of plants type which pH and ppm value have been set before, so farmers only need to choose the type of plants that they maintained to grown. The system started working by using of sensors connected to the electrode. Compared to renewed solution, fruit yield was decreased to about half (114.0 g plant−1) in non-renewed solution while non-renewed with DC-ED produced intermediate yield between non-renewed and renewed solution or non-renewed with AC-ED. It was concluded that growth performance was greater in renewed solution followed by non-renewed with AC-ED, while it was decreased significantly in nonrenewed solution with DC-ED similar to non-renewed solution. PlantTalk intelligence could be built through an arbitrary smartphone. All three linear actuators were driven by a 12 DCV relay board that communicates with a Phidgets interface board, which was connected to the main computer, which was running Ubuntu Server 11.04 × 64. If the relay of port pin is turned on, it means the water level is above of the specified height, and then the water pump will stop being water, in that manner the water flow was regular. After all these processes are completed, reports were produced by the system, based on the plant growth period [13].Hydroponic system setup.AHNPS was placed in a special chamber or vessel and the nutrients were supplied directly to the hydroponic roots at any given time (Figure 19). By filtering the detected lines, the edges of the gullies were identified. 93-1227. The inference engine, had the function to produce the results that the system needs by using the data in the knowledge base and by interpreting the rules of the system as follows; the user interface of the HES software and the relevant output values taken from the greenhouse system and the sensors are interpreted and translated into linguistic expressions such as low-high. The system conveys a properly balanced nutrient solution to the plant root area. This value is directly obtained from the sensor and sent to the Arduino. All gullies are oriented along the x-axis and are straight. The position node keeps track of the x, y and z-position of the robot and a graphic user interface was designed to provide low level control of the system. There were 25 samples evaluated. The program read the system configuration data that were stored in the SD card and initialized global variables with the configuration. Ion sensors (17 essential elements in plant nutrition) are still studied for their durability and stability [8].Hydroponics automation system (courtesy of over grower).It was developed a complete automation hydroponic system for maintaining stable electrical conductivity, pH, growth light and monitoring CO2, temperature and humidity. Water was collected at the end of the gullies and directed to the water reservoir, where a water pump propelled water to the top of the gullies. Simpler prediction methods, such as linear extrapolation and the lazy man prediction, value of the previous time step, gave comparable accuracy much of the time, though, they performed poorly in situations where the control actions of the system had been activated and resulted rapid changes in the predicted parameters. The controller circuit, in which main power supply was 12 DCV, providing power to the controller and relays, but it was reduced to 5 DCV for microcontroller by using a regulator of 7805 and relay (Figure 14).Controller circuit.The program providing the automation in the hydroponics system was simple and basic and very easy to load into the memory of the microcontroller, which repeated the actions throughout the whole growing season. An automated hydroponics system used in a greenhouse. Kurashina Y, Yamashita T, Kurabayashi S, Takemura K, Ando K. The nutrient solution pH in second and third block can be controlled faster than in first block. 2019;51:292-29720. PlantTalk: A smartphone-based intelligent hydroponic plant box. The coefficient of LED and ALI can be used to find daily light integral (DLI) during 17 h. The result showed each growing light produces difference intensity ranging from 6.03 to 10.74 µmol/m2/s, to fulfill plant light requirement on at least 17 h day−1. 2001;34(11):87-9011. The Kinect vision system was mounted on the carriage so that the optical axis was along the negative z-axis. Moreover, it has been designed a virtuino application on Android smartphone that serves to check the water level and temperature around the plants. After initialized an LCD module, then initialized serial and serial to PC for CO2 sensor. On the top of the cup a cross-hair is drawn to mark the center. Point was defined as the top left corner of the image. The future work will be collecting environmental data, which are obtained from sensors and implanting an artificial intelligence in robots and in hydroponics systems.It is also expected that in future research make the hydroponics systems and robots able to make information panel with other operating systems that can be used as a standard system.AdvertisementAILM was supported by PAICYT (CT696-19) and JMMJ was supported by PAICYT (CT571-18). p. The same phenomena occur in third block and the following blocks. This research introduces findings in design with real time operating systems based on microcontrollers; pH fuzzy logic control system for nutrient solution in embed and flow hydroponic culture; hydroponic system in combination with automated drip irrigation; expert system-based automation system; automated hydroponics nutrition plants systems; hydroponic management and monitoring system for an intelligent hydroponic system using internet of things and web technology; neural network-based fault detection in hydroponics; additional technologies implemented in hydroponic systems and robotics in hydroponic systems. An automatic mechanical system for hydroponics fodder production. 2001;34(26):37-4217. Kozai T, Niu G, Takagaki M, editors. IFAC Proceedings Volumes. In: Reed DW, editor. This system can be used for small producers from small hydroponic systems [11].HydroAS could produce fodder in 6 days. These days, there are microcontrollers (Figure 3) on the market that are compatible with a wide variety of sensors and can be used for automatic monitoring and robotics.Huertomato microcontroller for measuring of humidity, water and air temperature, light, pH, electrical conductivity (courtesy of Arduino).The emergence of Internet of Things (IoT) has allowed farmers to automate the hydroponic culture (Figure 4). When this happens, the elevator number two descends to the first storey and unloads the produced fodder to the conveyor. Licensee IntechOpen. A change in valve opening time, either for base tube or acid tube was due to the final output of the fuzzy. The output of this electrode will be forwarded to the microcontroller as an entry point to be processed by the microcontroller. The computer language used was C++ using the Open Computer Vision library. A timer was started up for minimum water and a sensor to detect the presence of water in nutrients within of a container. Above the NFT system were placed artificial lights to improve the lettuce growth. There are also powerful computers that could store all this information and build a big database.Schematics of internet of hydroponics (courtesy National Institute of technology, Trichy, India).It has been implemented a smart hydroponics system (Figure 5) that automates the growing process of the crops using Bayesian network model, which classifies and predicts the optimum value in each actuator to autonomously control the hydroponics farm [7]. 2018;91:61-6921. in diameter. Hydroponic systems, such as the deep flow technique, nutrient film technique or aeroponic systems, are essential tools in plant factories [4]. To change the pH solution from 7.0 to 6.0, it took 26 s and a 100 s to increase pH from 6.0 to 7.0. That indicated that at the same period of time [H+] freed by the H3P04 acid was more than that of the ion [OH−] freed by the KOH base.Pascal environment.The supplied voltage from PCL to relay circuit was on when the voltage reached 1.4 V and off when the voltage decreased to 1.1 V. The pH of the nutrient solution in first block can be controlled to approach the set point of pH = 6. pp. The extraction of the plants required combining classical 2D image analysis techniques and IR-based depth measurement the 3D position. It is used for all parameters temperatures, oxygen device, nutrition and the operating levels for water heater, fertilizer tube, pH balance, conditioner, moisture balance, carbon dioxide producer and artificial light are attuned, creating the appropriate conditions for the greenhouse system (Figure 18). Systems can be accessed through the web page using browser based on the server address. The pH sensor recorded the initial pH value in the solution, then adding the pH solution up 5 mL and compared the pH sensor measurements obtained with the instrument (Figure 9).Block diagram of system.A total of 600 s was taken by DHT22 humidity sensor sampling every 30 s and the readings were compared with the measuring instrument. Python programs for plant care intelligence through the smart phone were convenient (Figure 23). Sensors. On the design of nutrient film technique hydroponics farm for smart agriculture. AmHydro 612 NFT production unit was 1.8 m × 3.65 m × 0.9 m production unit that stored 144 plants and 144 seedlings and used a closed loop water system. London, England: IntechOpen; 2012. Both of valves frequently open in turns since the control load was still high at the start up. When the relay port pin is lower than the specified height, the water flow will be run on the water pump to irrigate the plant. In: IOP Conference Series: Earth and Environmental Science, Vol. USA: University of Minnesota; 20122. The position bias was removed by a linear scaling of the x and y-coordinates. The transpiration can be measured with either water ultrasound level sensors or load cells. Suhardiyanto H, Seminar KB, Chadirin Y, Setiawan BI. Because the Kinect is not located on the gripper, all coordinates have to be offset. Significantly greater fruit yield (225.9 g plant−1) was obtained from renewed nutrient solution, which was statistically similar to fruit yield in non-renewed solution with AC-ED application. The sensor detected if the water level decrease in hydroponic nutrition tube. Batavia, IL: Ball Publishing; 1996. All these processes are conducted by a computer unit where the relevant programs are loaded. The average temperature for five tests was 28.43°C. The relationship of water height in the nutrient tube with time is recorded continuously by the ultrasonic sensor on several measurements. The arm on the carriage was balanced by a counterweight and was driven by a stepper motor and a chain. 2018;978(1):01201415. Plant growth period is attained from the total of plant drain degree, plant nutrition degree, plant deterioration degree, plant photosynthesis degree and plant growth degree parameters. Time latency (in microseconds) was very small. A correction factor of 260 ppm was used for the MH-Z19 sensor against the initial value. From the results of pH meter sensor, the difference obtained is so small so that the pH meter sensor can be used to read the pH suitably. The system testing used the original plant samples to find out if the plant is growing well. The plants used in this test are pokchoy, lettuce and kale at the teen age period (after nursery). The actuators used were (a) two motors for the vertical movement of the elevators; (b) two pneumatic cylinder for the pusher; (c) two worm motors for the sowing platform and (d) two gearmotors for the rotational joint of the sowing and unloading platforms. In the case of the leaf lettuce growth in hydroponics with exposure to 28-kHz ultrasound and dissolved oxygen supersaturation up to 36 mg L−1 at 20°C and peak-to-peak pressure at 20 kPa or larger worked as the growth inhibitor of the leaves and the roots; in addition, oxygen supersaturation became a growth promoter, without any degradation of chlorophyll in the leaves [19].On the other hand, liquid separated reactor and a high voltage power supply based on a 20 kHz inverter neon-transformer were developed to archive the treatment with high energy efficiency, a low initial cost and a low running cost. The pH of the nutrient solution for most nutrient film technique is 6.0–7.0 for most plants grown in recirculating nutrient solution and 5.4–6.0 for substrate culture [6]. On the carriage was a mechanism to move an arm up and down (z-axis), down being the negative direction. Nutrient solution has been renewed when its EC level reached to 1.5–1.8 dS−1. The dosage of water was determined according to the pumping time of water. The hydraulic system supplied the nutrients and the flow of water in the system and consisted of two irrigation pumps to generate redundancy. The LM-35 sensor detected the temperature in Celsius degrees.Automated hydroponics nutrition plant system.The ultrasonic sensors measured the distance of water based on ultrasonic wave. After that, supplying of water has been stopped to the pump and then waited for 4 h of interval for the next irrigation session. Vivaldi grown in a deep–trough hydroponic system. The gullies laid on an inclined table, which angle was θ, so that water flows passively to the end of the gullies. Ultrasonics Sonochemistry. Before starting the design of a virtuino application, it first provides the data storage using the features of thingspeak.com.Experimental hydroponic system configuration.The hydroponic flow system starts from the detection of a proximity sensor and a temperature sensor (Figure 20). The pH of the solution did not change very much due to the small change in [H+] concentration. PlantTalk was flexibly to configure the connections of various plant sensors and actuators through a smartphone. After the hardware and sensors on the hydroponic NFT management system were integrated, the sensors (ultrasonic sensors, pH, temperature and EC) needed to be tested to quantify the level of accuracy. World Agriculture Towards 2030/2050: The 2012 Revision. The performance of the system is within the requirements and the plants could be manipulated on an NFT system [22].AdvertisementIt is expected that future developers can to detect acidity levels of pH solution, viscosity, oxygen and other variables. For instance, it was showed that the PlantTalk intelligence effectively lowers the CO2 concentration, and the reduction speed is 53% faster than a traditional plant system. All the commands on microcontroller (Arduino Uno) can be controlled from a smartphone-based Android. Hydroponic systems cover approximately 35,000 ha in the world and further research is needed to develop new hydroponic systems to reduce the cost of energy and materials required for crop production. 1-229. Up to 1.5 m the accuracy was 10 mm and the precision of the Kinect was 1 mm. After the water level 5 cm in the nutrient tube then the pump stops, and water did not flow anymore. When the system finds a rule that matches the related values in the rule base, it attributes this level value as the level value. 2012. The mechanical structure consists of the following parts: (a) mechanical structure of six storeys; (b) conveyor to exit the produced fodder off the system; (c) two elevators, at each top of the six storey structure; (d) a fodder sowing system, which placed the seeds in the trays; (e) two pushers at each of the elevator, which pushed the trays in the structure and (f) unloading system, which extracted the finished fodder in the trays (Figure 15).Fodder production system.The electrical components comprised the power, sensor and actuators circuits (Figure 16). The automatic solution comprised: the mechanical structure, the mechanical and hydraulic components, and the control system to automate the hydroponic automatic system. The maximum level of water was 6 cm in the hydroponic tube. Sihombing P, Karina NA, Tarigan JT, Syarif MI. System was capable to mix nutrients in 80 s with error less than 3.48%. The output only depends on the current state and the control input. The values were quantified by calibrating the Kinect. Scientific Papers, Series E, Land Reclamation, Earth Observation & Surveying Environmental Engineering. Each pot had the same amount of fertilizer and the drip irrigation system was used. The nutrient solution was decontaminated by 4 log cycle with plasma treatment under the continuous operation condition [20].Other researchers applied electro-degradation (ED) to the culture solution in order to degrade their root exudates and improve growth, yield and quality of strawberry. The excess water was easiest to return to the reservoir by the drainage pipes connected to the drainage holes of the pots. Conversely, if dE were negative, the error E decreased. The DFT systems (Figure 2) are long, cement or wood rectangular reservoirs and lined with a durable polyliner. The main hardware nodes were stepper motor node, gripper node, interface board node, position node and Kinect node. It was observed that this hydroponic plant grows well with proper water and nutrient usage because it is controlled by the microcontroller. Journal of Engineering in Agriculture, Environment and Food. The data base was made up of real conditions that summarize the current situation of the problem and quality-value pairs. If the roots are suspended in a liquid medium or supported using an inert medium, the system is known as Nutrient Film Technique (NFT). Electro-degradation of culture solution improves growth, yield and quality of strawberry plants grown in closed hydroponics. Hydroponics: Key to sustain agriculture in water stressed and urban environment. From the images with detected plants the gantry coordinates of the plants were calculated and inputted for the positioning algorithm so that the robot can be positioned to pick up the plants. The system consisted of an ARM Cortex-M4 microcontroller running ARM (Figure 8) embedded operating system, the official real time operating system (RTOS). Electrical conductivity of the irrigation water (ECw) was measured by an EC59 meter. By all these output parameters level management, the total level grade can be attained, and this can determine the development period of the plant.Graphic user interface of HES.This system had two rule bases. 2017. Editorial Elsevier, London, England: Academic Press; 20155. The flow rate of the nutrition used in this experiment was 2.4 L min−1 and the measuring apparatus was Hanna pH-meter (HI8710E model).The control system maintained 0.3 M H3PO4 and 0.4 M KOH, which flowed constantly from Marriott tube. Based on this voltage the microcontroller decided whether to drain the water at the pump or not. 2015;47:6313. Biological faults, because of their particularities, were treated separately [16].Other model based on a feedforward neural network predicted pH and EC changes in the root zone of Lactuca sativacv. Knowledge base is continuously in a process of improvement and human experts would add new knowledge to knowledge base or modify the existing knowledge heuristics when new situations occurs. A distance of 30 cm from LED to plant hole was settled to use a meter for Quantum PAR (photosynthetically active radiation). Communication technologies on this system using 802.11 or better known as Wi-Fi by using the internet (Figure 21).Hommons hydroponic system.The power supply using voltage 5 DCV and 2A. Various environmental sensors had been installed to detect any change in the physical or chemical environments and sensors became the input to the process management of NFT. After the user successfully performs the login process so the system redirected the user to the main page heading. Predictive neural network modeling of pH and electrical conductivity in deep–trough hydroponics. A timing belt transmitted the power from the carriage on the gantry to the stepper motor. The vegetable grew well and can be harvested in 5 weeks [9].The fuzzy-based control system was developed for maintaining a proper acidity level of nutrient solution used in potted flower cultivation of Chrysanthemum embedded and flow hydroponic cultures. Every hardware component communicated with its own ROS (Robotic Operating System) node. To evaluate the performance of the positioning and control algorithm, the x, y and z-position error between the final position of the gripper and the plant coordinate was measured. A solenoid valve was activated by a relay circuit, which obtained voltage from the computer.Process error (E) was calculated based on the difference between the set point (Sp) and the actual pH. If an E positive value was obtained, it indicated that the position of the actual pH was above the Sp and negative value of E indicated that the position of the actual was under the Sp. The error difference (dE) was the change in E to time. If the water level has decreased, then the sensor will perceive what occurs and automatically the water pump will be turned on to increase the water level on the hydroponic nutrient tube [14].It was created a hydroponic farm management system that could monitor water temperature, water level, higher densities of nutrient solution and the acidity of a nutrient solution using sensors are related and connected to the microcontroller via a website. User interface controlled the knowledge base of the expert system and entered data and realize operations. Perlite due to its characteristics has more advantages as being used in the hydroponics system as compared with peat and peat + perlite (1:1, v:v). Moreover, the straight line approaching the set point tendency of the error curve during the control indicates that the fuzzy logic control can maintain the solution pH at the set point. The neural net had inputs as follows: pH, EC, nutrient solution temperature, air temperature, relative humidity, light intensity, plant age, amount of added acid and amount of added base and two outputs: pH and EC. A combination of network architecture and training method was one hidden layer with nine hidden nodes, trained with the quasi–Newton backpropagation algorithm which was the most suitable and accurate (Figure 22). The system starts when the first storey is filled with trays. On the main content there were four columns that display data from the sensors-sensors on the NFT hydroponic farming tools, such as nutrient levels, nutrient pH levels, temperature, nutrient and nutrient EC and parts per million (ppm) level. of diameter PVC to flow the nutrient solution. Later program will update the LCD display. Alipio MI, Cruz AEMD, Doria JDA, Fruto RMS. Boca Raton, Florida, USA: CRC Press; 20163. A probabilistic Hough Transform was used for straight line detection. Time and date were displayed at any time of the process in an LCD screen. To reduce the noise, multiple consecutive frames were averaged to calculate the plant coordinates. A steel structure was built to keep pots at height of 1.5 m from the ground level of the greenhouse and water storage tank and controller circuit were installed immediately under the pots. The WiFi module sent the water level information and the temperature values of the plants area. Resh HM. The first one was the rule base that constitutes the input parameters and the second one was the rule base that determines the growth period of the plant. Şahin İ, Calp MH, Özkan A. The system controlled autonomously the desired agronomic conditions for production and fodder flow. Crisnapati PN, Wardana INK, Aryanto IKAA, Hermawan A. 2018;155:473-4866. The system defined the values that belong to the input parameters by using the output parameters that are used by the user (Figure 17). The irrigation system consisted of a 200 L water storage tank, containing Hoagland solution, which was modified to regulate the optimum 6.2 pH and electrical conductivity levels between 1.0 and 1.3 dS−1 for the green cuttings of grapevine. If the dE were positive, the error E had the tendency to increase. To be able to pick up a plant, the image frame coordinates had to be transformed to gantry coordinates. After reaching the set point. Fresh 25% standard Enshi nutrient solution were changed every 3 weeks interval, with in renewed treatment, while DC- and AC-ED treatment were applied in non-renewed solutions. The output of the control action was the duration of the solenoid valve opening depended upon the input signal. The open loop control algorithm was used. There were differences in the heads of the air inlet and outlet at the Marriott tubes for base and acid solutions, respectively. The output voltage from the PCL-812PG had a range of 0−+5 V. The debit of the base and acid flows from the Marriott tube was kept constant at 1.3 eels for base solution and 4.3 cm3 s−1 for acid solution. Two control valves maintained the nutrient solution pH at a desired set point as follows: (1) acid valve (to manage the addition of acid solution necessary) and (2) base valve (to keep the addition of base solution necessary) (Figure 11). To keep the plants in net pots, holes are perforated in a foam board which rest on the surface of the water.Deep floating technique (courtesy of Hydroponicsfarm).Aeroponic systems are very similar to NFT systems, differing primarily in the spatial arrangement of cultivation channels. Automation, robotics and IoT have allowed farmers to monitoring all the variables in plant, root zone and environment under hydroponics. The chosen microspray jets operate at 1 bar and have the capacity of 1 L h−1, with 0.8 m maximum spray diameter area. In NFT systems, the plants (lettuce, leafy crops and herbs) are grown in channels (gullies) and fed continuously at a rate of approximately 1 L min−1 (Figure 1).Nutrient film technique.On the other hand, if the roots are floating (pool), the system is known as deep floating technique (DFT). In the navbar a notification function button displayed the alarm or warning to the user while the settings button function settled the system (restart and shutdown) and logout of the system. The difference between the transmission time and the reception time became the water distance. The measurement result of the pH of nutrient solution was in the form of DC voltage and was transferred to 88 shunt circuit in order to get input voltage at a range of 0–5 V conforming to the working voltage of the PCL-812PG interface. This value was compared to the value in LCD microcontroller and on Android smartphone application. In: Proceedings of the International Conference of Agricultural Engineering CIGR-AgEng. 2019;243:243-25122. The pumps are used not only to increase water but also to add nutrients to the hydroponic tube. Monitoring of water level, pH, temperature, flow and light intensity can be regulated using IoT, which allows for machine to machine interaction and controlling the hydroponic system autonomously and intelligently employing deep neural networks [5]. of diameter as his planting medium and ¾ in. The culture vessel consisted of six blocks, each of which containing four potted flowers. On top of the gantry was a carriage that can move back and forth over the gantry (y-axis), this was perpendicular to the x-axis. Plant growth was observed by taking pictures of the plant for a few days [15].It was developed a fault detection model for hydroponic systems, with a feedforward neural network. Thus, the developed model successfully identified dynamic processes in the root zone of the hydroponic system and accurately predicted one–step–ahead values of pH and EC [17].Neural network model inputs and outputs and training process.An IoT-based intelligent hydroponic plant factory solution called PlantTalk was developed. If alarm is enabled, a relay will be also activated, and then the pump will drain the nutrition solution on the plant. It was also observed a similar trend in vitamin C content while brix and citric acidity was not varied. The strawberry yield and quality can be improved through application of AC-ED in non-renewed solution [21].AdvertisementRPBVF was developed to act and observe the crop in NFT hydroponic systems. Gazi University Journal of Science. Therefore, this chapter aims to be a practical guide to those interested in hydroponics automation and robotics to produce vegetables.Automatic grow cabinets for growing plants at home (courtesy of HG-hydroponics).Robot for hydroponic systems (courtesy of Iron Ox Company).AdvertisementAll possible variables in root zone must be monitored for automation of the hydroponic system and sensors of pH, the electrical conductivity (EC), light, the ambient temperature, the temperature of the solution, the humidity and the carbon dioxide, the dissolved oxygen and the oxidation–reduction potential must be considered as they directly affect the growth of hydroponically grown plants (Figure 7). Transactions of ASAE. This voltage became the reference digital signal for the computer to conduct data processing with control program. Light intensity measurement showed different result for different color spectrum in order to fulfill daily light plant requirement we need to turn on the light at least 17 h day−1. The field of view was of 0.8 m × 1.15 m in x and y-direction. Atmadja W, Liawatimena S, Lukas J, Nata EPL, Alexander I. This system had an embedded program module. After the identification of the edges, the lines were grouped, resulting in a segmentation of the gullies. A LED coefficient was obtained by dividing average light intensity (ALI) with lux. An overshoot not occurred in this pH control. Hydroponics is a method of growing plants in a water solution without soil. With these coordinates the robot is heading to the plant. They used four types of nutrient viz. After filtering, the coordinates of the plants in the image frame were known. Mechanical, sensor and biological faults were considered: a preliminary detection system detected the existence of any faulty situations. The sensor will detect the water level in the hydroponic tube and the temperature sensor to detect the room temperature. The detection sensor was connected to a relay that in turn was attached to the microcontroller port. To transform the image frame coordinates to gantry coordinates a Garstka and Peters modified transformation was used. The plastic box reservoir served to accommodate any mix of nutrient solution in water. Development of automatically controlled corona plasma system for inactivation of pathogen in hydroponic cultivation medium of tomato. The growing light intensity was measured at 25 cm from light source. This frequency decreased at the following blocks [10].A grapevine rootstock in hydroponics in combination with an automated drip irrigation system was developed, which consisted of a hardware and software of the automated hydroponics system for grapevine in pots. Calibration of the pH-meter was done on voltage basis using PCL-812PG interface. The error difference (dE) was the change in E to time. Twenty-five minutes were taken by MH-Z19 sensor with readings every minute in rooms, results were compared with measuring instruments. AgriTalk for a plant factory is an extension of PlantTalk [18].PlantTalk in a smart phone.It was applied ultrasound and dissolved oxygen supersaturation as external for controlling the growth rate of plants in hydroponics as well as maintaining the product quality. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences. This chapter is distributed under the terms of the Creative Commons Attribution 3.0 License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The power circuit consisted of depicted the protections and transformers to obtain 24 DCV to supply the S7–300 programmable logic controller (PLC), sensors and the command circuit, which were mainly digital, inductive and magnetic, that indicate start/end limits for the actuator's movement such as level sensors applied in the nutrients and water reservoirs. After unloading this tray, it is pushed to the first level for washing, and the next 6 days cycle then starts, to produce new trays full of fodder. Marriott tube was also used to calibrate the flow rate as well as on the relay circuit. RTOS gave good performance with latency and jitter less than 15 µs, system overall show good performance and accuracy for automating hydroponic plant in vegetative phase of growth. The ESP8266 module was used as a communication medium through a wireless network to the internet and integrated with objects that have connection to the internet. Romanian Review Precision Mechanics, Optics and Mechatronics. It was used a RPBVF algorithm was used to detect plants on the hydroponic system and placed the robot to manipulate plants (Figure 25).Hardware layout of the robot (a) and software layout of the robot (b).In the algorithm, first were detected the gullies, because the plants are only located on them. Takahashi K, Saito Y, Oikawa R, Okumura T, Takaki K, Fujio T. Nutrient solutions for

hydroponic systems. The focus is on the implementation of a position-based visual feedback (PBVF) algorithm in combination with a Microsoft Kinect. The system took over the irrigation events successfully for the whole growing season. Matos J, Gonçalves PJ, Torres PM. Once the water was activated, then timer watered the plants. The embedded system kept the plant growth media in 10 min, before it then flows back into the tank and flows into the next block. Pots were irrigated with the same amount of nutrient solution. CO2 data retrieval between MH-Z19 sensor and measuring devices at room had a difference for each room relatively equal amount, then for the sensor MH-Z19 in this case with a correction factor, so the results obtained are close to the results of measuring instruments. The plant coordinates form the control input for the robot. The development phase of the fodder was tested, and validated, which benefits the agricultural holding [12].HES was developed to minimize the labor force used in the process of hydroponics, the total amount of time spent in agricultural process, human-based errors, as well as, the control of hydroponics greenhouse plant production. Growing media: Types and physical/chemical properties. The nutrient solution control is also performed in the PLC, to control the pH and electric conductivity, while mixing the nutrients and the control sequence of the trays in the hydroponic system.Power circuit (a), sensor circuit for the unloading part (b) and actuator circuit for the elevator one (c).This sequence definition is a high-level control task, while the low-level actuator control is performed in inner loops and is programmed directly on the motor drives. An expert system design and application for hydroponics greenhouse systems. The computer program for the control system was developed using the Pascal language in DOS environment (Figure 12). Automation settings pages were divided into two parts: first part with its own set of pH and ppm values are desirable way entering the value in the textbox. The difference of humidity data retrieval between DHT22 sensors and measuring devices was very small. Two linear actuators were used to open and close the gripper and the other linear actuator was used to rotate the gripper around the y-axis. At the end of the arm was placed a two degrees of freedom gripper which opened, closed and rotated around the y-axis.Robot manipulator arm.The structure is made primarily from aluminum that allows the robot to be adjusted to accommodate different sizes of NFT hydroponic systems. Fonteno WC. The initial position of the gripper is defined as the middle between the points of the gripper so the x, y and z-position error can be measured. 109(1). The control action was based on decision matrix in which there are criteria of Quick Acid (QA), Fair Acid (FA), Slow Acid (SA), Neutral (ZO), Quick Base (QB), Fair Base (FB) and Slow Base (SB).The measurement result of the pH of nutrient solution was in the analog form of DC voltage and was transferred to defuzzification by means of weighting to the absolute membership value from every label with the membership degree obtained. The results showed that hydroponic automated system performed well. Automated hydroponics nutrition plants systems using arduino uno microcontroller based on android. The z-coordinate has to be offset by an extra value, because the NFT table is under an angle of 2.2°. The input parameters prepared the optimum growth environment for the plants. The rate of hydroponic plant growth was faster when compared with plants with soil-grown systems. The developed control algorithm was based on membership functions of fuzzy arrangement.Embedded and flow system with pH control system.Fuzzy rules had 21 linguistic statements to achieve smoothness, by trials and errors using the membership functions based on the operator skills and experience. Finally, the developed network, only considered two first kinds, mechanical and sensor faults. Each image was analyzed to detect the plants. Finally, we raise topics related to robotics for hydroponic systems (Figure 6). If the area or volume of culture is large, several sensors must be placed to adequately control the entire crop. Hommons used a 20 W solar system, which consisted of a solar cell panel, controllers, battery and DC to AC inverters. The fuzzy logic controlled nutrient solution pH and increased the smoothness of the pH the during control course. The required water was supplied by using 16 inches of diameter pipes with 4 L h−1-drippers at a spacing of 33 cm, with three drippers serving each pot. The hydraulic circuit comprised the valves, nutrients and water reservoirs, the six storeys pipeline with the irrigation micro-jets, and the 2 m3 water return reservoir with the two redundant pumps. Microcontroller (Arduino Uno) will control the flow of nutrient solution on the vessel automatically, and the microcontroller can be controlled from Android smartphone. To decrease the pH toward the set point it requires 68 s. The system initially provided nutrients for 5 mL and then the system recorded and calculated the amount of nutrients needed. The growth period of the plant is determined by adding the values of plant drain degree, plant nutrition degree, plant deterioration degree, plant photosynthesis degree and plant growth degree. 2019;12:315-3248. renewed, non-renewed, non-renewed with direct current electrodegradation (DC-ED) and non-renewed with alternative current electro-degradation (AC-ED). Trejo-Téllez LI, Gómez-Merino FC. 2002;45(6):200718. Open access peer-reviewed chapterSubmitted: April 20th, 2019 Reviewed: November 11th, 2019 Published: December 27th, 2019DOI: 10.5772/intechopen.90438Hydroponic system requires periodic labor, a systematic approach, repetitive motion and a structured environment. Ferentinos KP, Albright LD. If alarm is deactivated, the relay will be turned off and the pump will stop supplying. The x-axis was driven by a stepper motor and a chain. This process is repeated until the tray reaches the end. The system mechanism worked as follows: HC-SR04 ultrasonic sensor detected the height value of nutrient solution in hydroponic plants by the parameter of the high of water (in cm) unit and the temperature. C1429Submitted: April 20th, 2019 Reviewed: November 11th, 2019 Published: December 27th, 2019© 2019 The Author(s). The system controls the actuators of the mechanical structure. When taking data for RTOS experiment (Figure 10), the main programs still running while the experiment still ongoing.Experiment of RTOS.The yellow signal is a given signal and the other signal is a signal output from each thread. The nutrient solution flows into and fills the cultivation bench until a certain level, 5–10 cm from pot base. To accomplish with this, hydroponic systems must collect a lot of information, since this allows a better diagnosis of the problems and better understand the development of hydroponic crops. All software was programmed in C++. Hommons hardware design relationship of the NFT consisted of sensors, actuator, microcontroller, ESP8266, wi-fi access point, microcomputer (Raspberry Pi) and power supply. Every numeric variable was plotted into a fuzzy system consisted of Large Positive (LP), Fair Positive (FP) and Small Positive (SP), Zero (ZO), Large Negative (LN), Fair Negative (FN) and Small Negative (SN). The valve used was of solenoid type with 1/8 in. Growth control of leaf lettuce with exposure to underwater ultrasound and dissolved oxygen supersaturation. Automatic LED lighting, water spray, water pump and so on were included in the developed plant-care intelligence included and so on. This tray is then elevated to the next storey.

Subaru's EJ251 and EJ252 were 2.5-litre horizontally-opposed (or 'boxer') four-cylinder petrol engines. For Australia, the EJ251 engine was first introduced in the Subaru BE/BH Liberty in 1998 and subsequently offered in the BH Outback, GD/GG Impreza RS and Subaru SG Forester. For the Subaru BL/BP Liberty and BP Outback, the EJ251 was replaced by the EJ252 engine. An IDM Properties & Services maintenance call system has been put online to facilitate a more efficient service to the IDM research groups with regards the logging of maintenance jobs and their subsequent monitoring. Exploiting the uniqueness of the soloMERTM technology for the development of next-generation, super-potent drug modalities for chronic autoimmune inflammation diseases, and beyond - April 2022 Opportunities and Challenges in Early-Stage TB Drug Discovery: Targeting DNA Replication as a Case Study - April 2022 分类专栏： PHP快速开发工具箱（一百个插件工具） 文章标签： dictionary action function download spring string 版权声明：本文为博主原创文章，遵循 CC 4.0 BY-SA 版权协议，转载请附上原文出处链接和本声明。

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