Team ID	**PNT2022TMID30802**
Project Name	**SmartFarmer - IoT Enabled Smart Farming Application**
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SMART AGRICULTURE

ABSTRACT:

Farming is a major input sector for economic development of any country. Livelihood of majority of population of the country like India depends on agriculture. In this project, it is proposed to develop a Smart Farming System that uses advantages of cutting edge technologies such as IoT, Wireless Sensor Network and Cloud computing to help farmers enhance the way farming is done. Using Camera to get information about the field and help farmers to take precise decisions on insights and recommendations based on the collected data. The age calculation helps to maintain required water-level in the farming. The water-level in the farm is maintained by application controlled water pumping motors which is controlled by the microcontroller. The piezo electric sensor is used to generate the frequency of the wings of ‘Dragon fly’. The insects will go out of land because the ‘Dragon fly’ is natural enemy of insects. The device is IoT enabled by connecting to Wi-Fi using Arduino Uno.

CHAPTER 1

Introduction

This document delivers an overall assessment of the conceptual prototypes of the two SmartFarming sub-use cases “SmartGreenhouse” and “SmartSpraying”. Special emphasis is put on the impact for end-users. The sub-use case related functionalities were further evaluated with endusers and documented.

The target audience are the project partners within the FutureInternet project and decision makers, but also end users such as farmers and developers of agricultural software who want to be aware of future trends. A major part of the results provided in this document were obtained by user evaluation. Another important source is a benchmarking study. Last not least relevant input was provided by the developers of the pilot application, which was further investigated in desktop research.

The main challenge of today’s agrifood sector is to meet the increasing food demand and at the same time reduce the ecological footprint of food production. The agrifood industry has also to provide more transparency to allow a better feedback on how the political, economical, social and health requirements are met. These targets can only be reached by a knowledge driven industry with ICT as a key factor. This document analyses how the SmartFarming sub-use cases can contribute to meet the challenges of future agri-food production.

The results of the validation of the two pilots with end-users are presented in 2. The following chapter evaluates the economic, environmental and social impact of the SmartFarming use case. 3.2. analyses how the pilots can contribute to a more efficient use of resources.

Some considerations can only be given as an indication or potential of what is to be expected. Definitive numbers require actually implementing and deploying the pilots on a larger scale.

As described in the section 3.4.1 the software architecture in SmartFarming pilots follow SOA paradigm. Both pilots consist of a set of un-associated, loose coupled services that are published as RESTful Web APIs. The SmartFarming pilot specifications presented in the deliverables 200.3 and 500.5.2 give comprehensive easy to follow top-to-bottom view to the pilots. The purpose and the functionality of each module are presented as stories, self-explanatory tables, class diagrams and data flow diagrams. On the top of these the RESTful Web API descriptions describe the publicly available interfaces for third party service message exchange and communication. Following the specifications the underlying functionality of the software modules can be implemented using any programming language that supports REST binding. The main focus is on standards and protocols in message exchange between interfaces.

The existing legacy systems can be connected to the pilot systems by

- encapsulating them using REST architecture
- using ESB (enterprise service bus) technology
- using direct connectors when applicable and the only alternative

When it comes to embedded sensors the best way to connect them is to use Internet of Things (IoT) Services Enablement encapsulation as described in related FI-WARE chapter.

This document thus provides the results of the user evaluation and evaluates the technical perspective, but also the overall impact of the SmartFarming pilots.

1 Validation Results

1.1 User evaluation of the pilots in Finland and Greece

In this section a report is given of the end user validations accomplished within WP200 devoted to develop Future Internet based smart farming technology. The technology development took place in developing two pilots Smart Spraying and Smart Greenhouse. These pilots draw on same technological bases as has been described in the D200.2 and in the forthcoming D200.3. Both pilots have been designed from a usage-driven perspective. This means that end-users’ needs in greenhouse and arable farming activities were identified and user requirements were formulated as central design goals. Recurrent design workshops and repeated end-user evaluations during the entire development process were also accomplished. The process of a usagedriven design and evaluation process was conceptualised by a model that was labelled V7 model (see D.200.1). The model defines seven steps via which research and design efforts are combined to deliver a gradually maturing design output. These steps portray two types of efforts, i.e., expert-based design tasks and different design and evaluation – oriented interactions with endusers. In the sequence of steps these two types of tasks alternate systematically (see Figure 1).

Figure 1: The usage-driven design and evaluation model, the V7 model, used in the WP200

1.1.1 Intermediate evaluation results of Smart spraying (Finland)

In this and the following section 2.1.2 the end-user validation of the Smart Spraying System will be presented. The Smart Spraying System design and development was accomplished in Finland by the joint effort of MTT and VTT. MTT was responsible for the farming domain expertise and for the technical design of concept, whereas VTT was responsible for the end-user validation.

Following the V7 model the first 5 validation steps were accomplished by May 2012 and reported extensively in D200.2. A summary of the intermediate results is given below.

Step 1: System models for the smart farming as part of the IP-based food chain

The usage-driven design and evaluation the Smart spraying pilot concept was first put into the context of the entire food chain. A model was developed that demonstrates how the actors of all the studied three food chain processes (farming, logistics, and retail activity) must take into account the global food chain challenges, i.e. food safety, environment, ethical issues and cultural preferences. The consideration of the global challenges becomes evident in the decisions taken when accomplishing each of the main activities of the chain; farming, logistics and retail. Each of the three activities would have to optimize between specific goals and define the optimisation criteria.

What comes to the Smart farming (spraying) the business models were tentatively defined to identify the basis of the farmers' decision making while optimising between goals. An initial list of business goals was identified. In the following those values that were identified by the endusers to have great value are indicated:

- Avoid possible crop damages and machine damages
- Produce more qualitative products by less pesticides
- Decrease the cost of investment effortlessly
- Be provided with technical support immediately

- Link easily with other stakeholders
- Better link with government and certification authorities
- Reduce tractor down-times and increase maintenance and repair cycles

The connection of these generic business values to decision making in smart spraying situations was also studied with the aim to understand the information requirements of the FI-based services. It was found that the smart farming work process focuses on optimizing between the following goals:

- Safety of the product (food safety): Pesticide residue relates to the consideration of the safety of the end product. In order to monitor this optimization goal the actor needs to pay attention to his/her pesticide usage and that the usage fulfils the set rules and norms.
- Environmental values: Wind drift is one of the most important goals of optimisation that relates to accounting environmental values. The criterion is observing the wind direction and velocity while spraying.
- Environmental values are also portrayed when considering the carbon footprint goal. The criterion to observe by the actors is that fuel consumption is kept under set carbon dioxide limits.

Step 2: End-user needs

In this step end user needs were conceptualised on the basis of interviews and focus groups which were carried out in five countries within Work Package 700 of SmartAgriFood project. Participants expressed limitations of present farming situation with currently available technical equipment and also brought up their needs and expectations from the future technology:

Information and data: limitations and expectations:

The information available on the internet presently was felt limited, it is not appropriately specific or detailed or the databases are not available and/or expensive. In many cases most of the available information is inaccurate and unreliable.

- The most important need is sufficient information (weather and ambient conditions, soil conditions etc.) collected into a connected database.
- Getting the right information or sharing the information and knowledge with the neighboring farmers – via a shared infrastructure - was found important.

- There are not appropriate sensors or the existing sensors are inaccurate. This is particularly true for the GPS systems used.
- Sensor information could be useful. Monitoring the health status of the crop and animals or weather and ambient conditions continuously can be ensured by using a large amount of sensors. Sensors to measure temperature/humidity are also important for the farmer for identifying if crops are degrading or the likelihood of pest or disease development.
- Using a network of sensors or at least connecting more sensors to each other is also a basic criterion for a well-functioning, improved system.
- An advisory system can provide some sort of a market price e.g. for specific plants on a specific area, thus some investment decisions can be made on that basis.
- Communication of machinery with the farm management information system, where each machine and each tractor should be able to communicate with the farm, and the high data transmission rates could ensure that data exchange never would cause delays in the field work.

Communication and data transfer: Limitations and expectations:

- The communication within a farm or between the partners is too slow.
- Large sized files, photos and videos cannot be transmitted.
- In many regions there is not complete network coverage (e.g. the web is not accessible) or the internet services are hobbling because of network congestion.

Applications and devices: Limitations and expectations

- The current devices and files cannot be combined with each other and are not standardized. The applications are segregated and are not used, or cannot be organized into a system.
- There are no appropriate applications or the applications and solutions are too expensive, in addition the use of these applications is often very complicated.
- Users usually have limited information about the new technologies and cannot imagine and interpret the operation and the exploitation of the envisaged functions of the FI.
- For achieving the availability of the future internet the compatibility of the different applied devices, programs and systems or the integration of systems instead of different

connected applications should be ensured and there is a need for longer range in data exchange/transfer and in communication.

Security, good availability and quality of information: Limitations and expectations

- Ensuring of safety and security of data and information is a specifically essential element of the Future Internet. Most of the users are worried about the unauthorized use of their data and they require that the expected systems and applications should be safe.
- Availability of databases should be regulated and controlled to guarantee the data security and protection.
- Prioritization of information is important. Selection of the relevant, important and reliable information and proving its verity is equally important than to collect and distribute more and more information.
- Services, the equipment, the devices, etc. should be available everywhere and they can operate their business processes remotely from anywhere and it is necessary that the applications and devices should be integrated and standardized.

It appeared that the users have limited information about the new technologies and FI functions. Also there is a need to draw attention to the importance of explaining the potential opportunities, functions and applications of the FI for the users in non-ICT, user-friendly style. There is a need to make repeated efforts on clear explanation of the new opportunities and functions of Future Internet in a user friendly style.

Step 3: User requirements and use cases

In total 29 mini use cases were identified for the smart farming domain (see D200.1, Appendix A). These use cases were summarised to form architectural requirements and further grouped into functional blocks relevant to the system architecture. The results are further utilised in the development of the specific pilots.

Step 4: Integrated design of the architecture

The first result of this design step is the set of conceptual models of the Smart Spraying system from the usage point of view. Two types of conceptual models were constructed.

The first model was an overall model that makes explicit the connection of the Smart Spraying Pilot to the overall objectives of the food chain. The second model provided a conceptualisation of the core-task demands of smart spraying, and the innovative technology concept divided into functional requirements and innovative solutions. End user evaluations concerning the main innovative solutions of the model were received as follows.

General

- The Smart spraying project was found challenging because there is already existing infrastructure in farming field and one big concern is how that can be connected to the new internet supported infrastructure.
- Adopting this kind of future internet supported farming system demands a change also in the farming/working culture.
- The farmers did not think it would be impossible to mark their own information in the cloud appropriately. Defined ownership of information is essential if one is going to sell and develop new business around it.

Solution 1: Tailored services: Integration of external and internal data for tailored spraying services

- Potential is seen when local (e.g. micro level) information can be easily connected with the data provided by other service providers/ sources and in this way made even more accurate and suitable for own purposes.
- Micro weather information service would be useful for local farmers and could potentially create some new business. It is important to know if it is going to rain within two hour or eight hours.
- Main challenge is that different equipment does not communicate with each other. All systems so far have been closed.
- It would be useful if it would be possible to collect the weather information from many local actors and aggregate that as an “own weather” service. This could then be used for optimizing own farming process. The farmer could also develop refined services for sale for other purposes (e.g. local holiday weather). All bigger service providers base their weather information on Foreca’s weather forecast but in the micro weather there is the real potential. Basically you could even go underground and get soil information.

- The idea that the farmer can choose or adapt the services for his/her own use is really good. That created a possibility to modify and alter the services according to own needs.

Solution 2 Recommendations: Aggregated recommendations for decision making in spraying tasks

- Many useful recommendations for spraying task was envisioned and all of them were emphasizing that most value can be created if the spraying is done only when there is a real need for it.
- Already now, local weather information is collected from local small scale weather stations. But, there is no added value in collecting the same information that can be already provided by the national weather organizations (e.g. through radar pictures). The potential is on feeding the macro weather with micro weather information. In this way we could provide flora specific operation recommendations.
- For example, the disease alarms are mostly based on macro weather but in fact it is the micro climate inside the growth that determines that real risk.
- The Meteorological institute has already radar pictures that are sensitive enough to detect swarm of insect but this information is actually not used for that purpose. So the data already exists and maybe through this future internet it could be made usable/available for farmers.
- Precise weather information is useful for optimizing for example the order of spraying in larger areas, e.g. by spraying contractor in customers fields.
- The value of this system is that you go for spraying only when it is needed.

Solution 3 Context aware work support: Timely service offering and information presentation according to spraying process

- It could be a big item of expenditure if it could be possible to get better information about the real need for spraying or support for optimizing the driving order.
- The reliability of the internet connectivity in farm areas can still be a problem for applying all these services. Few years ago it was sometimes problematic even to get mobile calls through because the bad network covers.
- Especially the restrictions of the internet connection come true when there is a need for handling larger data file (e.g. video feeds).
- This system would be really good for contractors. The contractor would have easy access to his/her customers' field information. The contractor also could more easily discuss

about the need and timing for spraying if there would be background support from the future internet services.

Solution 4 Synthetic feedback: Reporting by documenting connections between conditions, actions and outcomes

- One general goal that can be seen in the future farming business is the demand for increasing production efficiency and the other is reducing the environmental effect.
- Agricultural E-learning through internet is the future. Farmers do not have time for long education/ training periods. They want to study remotely so that they can at the same time manage their farm activities.
- It would also be useful if the farmer could choose/ select the parts of the curriculum that are relevant for him/her

Solution 5 Food chain communication: Established communication channels with different stakeholders

- The possibility for genuine two way communication within the food chain can bring added value for farming business.
- It would bring added value for the consumer if he/she could get the precise information concerning different products' food chain history in the grocery store. In this way also part of the farming information could be communicated all the way to the consumer.
- It can also work other way around. For example, some consumer groups might want some specific kind of food, e.g. because of food allergies, or other personal reasons. Farmer could use this information coming from the consumer to adjust his own farming process.
- Consumer information is of course important but it is also a bit more dynamic and unpredictable than the question of production efficiency. You never know what it is going to be tomorrow that people are talking about and interested to purchase.
- For activities that needs to be performed within short time window effective communication and optimization is essential. At the moment in the farming business (compare to the forest industry) there is still a lot of room for improvements.
- Traceability from farm to fork is important. There are still holes in the food chain traceability. By providing traceability information from own products (e.g. documenting whole process in its details) it could be possible to get also better price from them and more meaning for own work.
- Vilppulan Tattariosuuskunta, a producer community in Finland, produces a few functional food products that for example corn allergic person can eat. The food is treated in a

special way in the production process. They have special interest for this because they know the process from thoroughly and can generate added value from it.

- Consumers are interested in how their food is produced.

The end-user evaluations concerning the Smart spraying concept confirmed the potential of the innovative solutions of the Smart spraying concept. When discussion took place with farmers who have previous experience of ICT-based farming technology the potential advantages of the Future Internet –based technologies could be identified. The farmers also saw broader benefits of the FI-based farming like new forms of collaboration and learning.

On the basis of end-user feed-back and developing inputs of FI generic enablers the concepts were developed further. New elaborated versions of the conceptual models are provided in the present report in section 2.1.2.2.1

Step 5: Scenario-based concept construction

Bizagi modelling techniques was used as a tool in the conceptualisation of the functioning of the system architecture in the use cases with the aim of which the pilot would be demonstrated. This step was engineering-oriented but exploited end-user evaluation results achieved so far.

Next steps

In the present deliverable the accomplishment of the 6th step of the validation and the results will be described. The reporting of the final step 7, which includes the integration of the Smart Spraying pilot to the experimentation of the large scale pilot in the eventual second phase of the Future Internet project, will be reported in the outputs of W600, i.e. D600.4

During the last months (after May 2012 until October 2012) of the smart spraying pilot development the concept was significantly elaborated. When the concept had thus far focused on smart spraying and a selected scenario, the concept scope was enlarged to cover also a smart farming service concept. The enlarged pilot can now be labelled as Smart farming Concept and it includes both service level and spraying concepts and proposals for corresponding user interfaces. The elaboration of the pilot will be elaborated in the following.

1.1.2 Final evaluation results of the Smart spraying/farming pilot (Finland)

1.1.2.1 Evaluation methods

The evaluation approached followed the V7 model. The 6th design and evaluation step was accomplished and several different methods were used, including a design workshop 2 with two separate sessions. Between the two end-user sessions the Smart spraying concept was elaborated further. The concept labelled Smart farming now includes two parts: The Smart service and the Smart spraying. These two parts have been presented to the end-users either on conceptual or also on user-interface level. Finally the elaborated concept was also discussed in the national panel organised within the WP700. These methodical means of gathering end-user evaluations are described below.

1.1.2.1.1 Design workshop 2: Evaluating the concept

Target: Test of the service and spraying parts on concept and corresponding user interface levels. The target will be approached via the design workshop 2, which includes two separate sessions and a user interface development that takes place between the two workshops.

Session 1: Vihti 28.6.2012

A workshop session was organised at MTT Vakola site in Vihti, 28th June, 2012.

Focus

The workshop focused both on the smart service (initial form) and the smart spraying concepts with the aim to elicit detailed data of the information needs of the famer in planning and accomplishing a spraying task. (User interfaces were not presented and dealt with in detail).

Method and participants

The Critical decision method [1] was used in the interview. The methods are applied individually. According to this method the participant is requested to propose a challenging event that s/he has personally experienced that would demonstrate the constraints in the task and system under study. Thereafter in several successive phases, called sweeps, the event is analysed in detail. The interview was audio-recorded and transcribed into a written protocol. Two farmers participated in the workshops (so far only one session has been analysed in detail but it will be included in the final report of the case which is going to be submitted in a scientific conference during 2013).

We also collected field data of spraying activity. This was accomplished by videotaping one entire spraying event by an overview camera and a head-mounted camera which shows the direction of gaze (but not eye movements in detail). This information provides detailed information of the actual use of information and accomplished operations during a spraying session. This data will be used when demonstrating the added value of an FI-based on-line support of spraying (to be included in the above-mentioned scientific report).

Concept and User interface development

Focus

As indicated above the Smart spraying concept and pilot was elaborated during the last design phase (June-October 2012) MTT Smart Spraying System developers and VTT human factors experts developed in collaboration the system to include two parts, the service and the spraying parts, and two levels i.e. concept and interfaces were developed for both parts.

Method and participants

This step comprised of technical and human factors engineering work in which MTT and VTT experts participated.

Session 2: Jyväskylä 25.-26.10.2012

Focus

The smart farming service and spraying concepts and corresponding user interfaces were presented and evaluated. Method and participants

The developed concepts and user interfaces were demonstrated to the participants of a national KoneAgria fair (Agrimachine) in Jyväskylä at the 25.-26.10.2012. The concept was described on a poster and was explained to interested visitors to the MTT stand by the researchers. The user interface was demonstrated on computer screen and also by smart phone application. 15 interviews could be completed among the participants of the KoneAgria fair.

National discussion panel 24.10.2012

Focus

As an activity of the WP700 VTT and MTT organised a national discussion panel at VTT Otaniemi site, on the 24.10.2012. In this session four pilots Fruit and Vegetables, Tracking, Tracing and Awareness Meat (TTAM), Tailored Information for Consumers (TIC) and Smart Spraying pilot were presented to the participants for comments. The Smart spraying pilot was presented including the service and spraying parts, and it was discussed on conceptual level (the user interfaces were not discussed in detail).

Method and participants

The pilots were presented in about 10-15 minutes presentations. The presentations were prepared by the Finnish SAF research group. After the discussion panel we had a common group discussion within the research group to filter out our main conclusions of discussion: the key points from the discussion, relevant for the pilots, concerning in particular information production in the food chain and information management.

In order to get more diverse response from the participants, the 5-page questionnaire was developed and shared in the beginning of the meeting. These questions considered the views on the main challenges of the food chain, the effect of the pilot on the process development, the challenges and threats of the usage of the pilot and views on changes in business environment. One of the researchers recorded in writing all the discussion and a back-up audio-recording was also taken.

18 end-user representatives participated in the panel. 5 researchers were present to support the discussions and recording.

Results

1.1.2.1.2 Focus of evaluation: Concepts

Overview of the smart farming concept

The original overview model of the smart spraying concept was improved according to the elaboration of the pilot MTT and VTT decided to accomplish. The main elaboration concerns the inclusion of a Smart farming service framework part. It supports the initial Smart spraying sysThe model also demonstrates that the smart spraying concept has been elaborated with regard to one work process phase, i.e. execution. The use case used to elaborate the Smart spraying concept element is “Machine break down” scenario. This scenario is described in detail in D200.3.

The Smart farming pilot conceptualisation is always accomplished on three levels: Value (green level), Concept (orange level) and User interface (yellow level):

- The value level refers to value propositions concerning the activity under discussion (also business models) and the core-task demands of the work to be accomplished with the aid of the defined system. Included are also so-called user experience targets (UX targets) which define work-related expectations with regard to the development of work when the new system is implemented.
- The concept level refers to the usage-driven requirements and the solutions that are proposed to fulfill these requirements. This level is supposed to define the innovative features of the designed concept from the point of view of the aimed work or usage. Because the work or other usage is described in functional terms, i.e. in generic core-task demands of the work and value propositions expected to be reached when enabling technologies are introduced, the description is future oriented.
- The user-interface level refers to specifically usability-related (requirements and) solutions. These parts of the model are not presented in detail conceptually but instead are demonstrated via visual solutions.

Smart farming service framework

As indicated above the Smart farming service concept (as well as the Smart spraying concept) was defined on three levels, i.e. value level, concept level and user-interface level. The proposal for the Smart farming service framework is to be found in Figure 3.

Value level: In the case of the Smart farming service the value level was defined with regard to the added value of the proposed concept. The added value that was found relevant for the farmers are expressed in the form of value propositions presented on the “green level” of the service concept model in Figure 3. Five value propositions were formulated.

- Networking, i.e. access to services
- Providing more high-quality food products
- Documenting all processes
- Environmentally friendly production
- Improved resource management

With regard to Networking and access to service possibilities to create links between machine manufactures, governmental agencies and authorities, industries processing their products were conceptualised. These links are seen particularly important in the planning phases of the production work. There is also an on-line need for access to services while accomplishing particular farming tasks, e.g. spraying. A seamless spraying experience is valued as a future expectation what regards the execution of work on the field.

Providing more high-quality food products was also conceptualised as an important value added by the Smart farming service framework. Improving high quality is possible due to better planning that the network could support, e.g. in the form of better mastery of chemical interactions when selecting spraying substances, but also due to the on-line services that could be provided for monitoring and alarming of plant diseases. It has become clear during the planning of the concept that farmers are well informed and concerned of the need to control well the residues of chemicals in the final products.

Documenting all processes in farming is a demand that characterises a modern farming activity. Smart farming service concept should enable better reporting and facilitate more automatic recording as much as possible. An improved reporting is a possibility for them to establish highquality brands. Reporting should increase trust within the food chain, and also improve the possibility to inform the consumers about the products. In this connection also more generic benefits for registering could be identified. Advantageous for the future development of the agricultural domain would be that better information of farming activity could be delivered to the governmental bodies and to research.

Environmentally friendly production was also considered as an added value of the Smart farming service framework concept. In this connection the benefits were clearly connected to better control of the chemicals used, and via this, better justification their usage in fighting plant diseases or insects.

The final value proposal that was identified concerned the improved resource management of the entire farming activity. It is clear the good planning is important and it could be facilitated by FI-enabled networks, but on –line resource management in highly intensive working periods of the growing period would also provide added value.

Concept level: On the concept level of the Smart farming service framework all together 7 concept elements were identified. The elements indicate what are the innovative features that the Smart farming service framework would provide for the users. We identified the following innovative features:

- Access to service in the market
- Tailoring of services
- Awareness of service events
- Offering services to the market
- Cumulative farming experience
- Food-chain communication
- Service synergy

The innovative concept features are depicted in Figure 3 as the upper "orange level". These features are thought to enable a new type of farming work. The features enable purchasing of services for own production and it also facilitates offering services for the farming community, or to the market. Accumulation and delivery of information for farmers' own benefit and learning and also throughout the networked farming activity and food chain, are also enabled by the proposed concept.

On the concept level we identified seven solutions that would be needed to realize the designed concept. These were (see also Figure 3, lower "orange level"):

- Marketplace registration
- Service registration
- Easy change of service provider
- Notifier (alarm) integration
- Vertical information exchange between third party services
- Use of IoT service enablement for open service building
- Third party service user interface exchange and embedding

The above solutions were identified in close connection with the MTT technology developers (especially Markku Koistinen), and are integrated in the design Smart farming service design based on the FIWRE generic enablers (see D200.3).

Smart spraying system concept

The Smart spraying system concept is presented in Figure 4. The value level (green) of the Smart spraying system focuses on the core task demands on the actor and the user experience targets (green).

We succeeded to identify 6 major core-task demands to the Smart spraying work. These were derived on the basis of earlier core-task definitions for precision farming [2] and concretized to fit the particular work of spraying. The core-task demands describe psychological work demands that are necessary for fulfilling successfully the aims of the work. The focus in defining the demands is in the goals, constrains and possibilities of the farming process itself. In each box of Figure 4 (green), the bolded title defines the core-task demands of farming activity, under which typically three sub-demands were identified (normal text) to apply in particular the smart spraying task. The aim is that the technology concept developed should fulfil these demands.

The user-experience targets are seen to follow from the logic according to which the farmers take the core-task and production related demands into account and what they consider as good professional work. The user experience (UX) targets is the final result of the end-user evaluation of the Smart Farming pilot and we shall return to it in the end of the result presentation in section 2.1.2.2.4

With regard to the concept level Figure 4 provides the main innovative features of the Smart spraying technology concept from the point of view of the farmer. Functional requirements and the solution are identified. The thereby defined technology concept should support the fulfilling of the UX targets and the core task. We have identified six concept level functional requirements and five solutions that should fulfil them. The functional requirements that we thought to be of most importance to the famers in their spraying task are:

- Remote monitoring of spraying
- On-line re-planning of spraying task
- Resource coordination including human actors and automation
- Agronomical decision support
- Cumulative operating experience
- Food chain communication

Details of the requirements are indicated in Figure 4, upper orange boxes.

The innovative features of the concept include also the solutions that should tackle the requirements. The solutions are based on Future Internet technology. This enabling technology provides characteristics to the system that are novel also to those farmers who have experience of Farm Management Information Systems, or who are used to exploit Internet services for specific needs.

The innovative solutions from the farmers’ point of view are proposed to be,

- Tailored services by combining internal and external data
- Aggregated recommendations for on-line decision making
- Task-aware and timely presentation of information
- Context-aware work support
- Synthetic feed-back from operations
- Food chain communication

CHAPTER 2

LITERATURE SURVEY

1. **AgriSys: A Smart and Ubiquitous Controlled-Environment Agriculture System**
2.

Aalaa Abdullah, Shahad Al Enazi and Issam Damaj, American University of Kuwait, Department of Electrical and Computer Engineering, Salmiya, Kuwait

With new technological advancement in controlled-environment agriculture systems, the level of productivity has significantly increased. Agriculture systems are now more capable, reliable, and provide enhanced productivity. An agriculture environment can range from a single plant in a house, a backyard garden, a small farm, to a large farming facility. These agricultural automated systems will help in managing and maintain safe environment especially the agricultural areas. In this paper, we propose a smart Agriculture System (AgriSys) that can analyze an agriculture environment and intervene to maintain its adequacy. The system deals with general agriculture challenges, such as, temperature, humidity, pH, and nutrient support. In addition, the system deals with desert-specific challenges, such as, dust, infertile sandy soil, constant wind, very low humidity, and the extreme variations in diurnal and seasonal temperatures. The system interventions are mainly intended to maintain the adequacy of the agriculture environment. For a reduced controller complexity, the adoption of fuzzy control is considered. The system implementation relies on state-of-art computer interfacing tools from National Instruments as programmed under LabVIEW

Drawbacks:

• The advances in pervasive computing and the Internet-of-things are to reach every aspect of life including local agriculture practices.

2. Smart Farming – IoT in Agriculture

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IoT is a revolutionary technology that represents the future of communication & computing. These days IoT is used in every field like smart homes, smart traffic control smart cities etc.

The area of implementation of IoT is vast and can be implemented in every field. This paper is about the implementation of IoT in Agriculture. IoT helps in better crop management , better resource management, cost efficient agriculture, improved quality and quantity , crop monitoring and field monitoring etc. can be done. The IoT sensors used in proposed model are air temperature sensor, soil pH sensor, soil moisture sensor, humidity sensor, water volume sensor etc. In this paper I surveyed typical agriculture methods used by farmers these days and what are the problems they face, I visited poly houses for further more information about new technologies in farming. The proposed model is a simple architecture of IoT sensors that collect information and send it over the Wi-Fi network to the server, there server can take actions depending on the information.

Drawbacks:

- Permitting ranches and other agri-food on-screen characters to adapt the information they are delivering.

3. A Model for Smart Agriculture Using IoT

Prof. K. A. Patil, Assistant Professor, Department of Information Technology, MET's BKC, IOE, Maharashtra, India. Prof. N. R. Kale, Head of Department, Department of Information Technology, MET's BKC, IOE, Maharashtra, India

Climate changes and rainfall has been erratic over the past decade. Due to this in recent era, climate-smart methods called as smart agriculture is adopted by many Indian farmers. Smart agriculture is an automated and directed information technology implemented with the IOT (Internet of Things). IOT is developing rapidly and widely applied in all wireless environments. In this paper, sensor technology and wireless networks integration of IOT technology has been studied and reviewed based on the actual situation of agricultural system. A combined approach with internet and wireless communications, Remote Monitoring System (RMS) is proposed. Major objective is to collect real time data of agriculture production environment that provides easy access for agricultural facilities such as alerts through Short Massaging Service (SMS) and advices on weather pattern, crops etc.

Drawbacks:

- Over period, weather patterns and soil conditions and epidemics of pests and diseases changed.

4. IOT Based Smart Agriculture System

G. Sushanth1 and S. Sujatha2, Department of ECE, Christ University, Bangalore, India.

Smart agriculture is an emerging concept, because IOT sensors are capable of providing information about agriculture fields and then act upon based on the user input. In this Paper, it is proposed to develop a Smart agriculture System that uses advantages of cutting edge technologies such as Arduino, IOT and Wireless Sensor Network. The paper aims at making use of evolving technology i.e. IOT and smart agriculture using automation. Monitoring environmental conditions is the major factor to improve yield of the efficient crops. The feature of this paper includes development of a system which can monitor temperature, humidity, moisture and even the movement of animals which may destroy the crops in agricultural field through sensors using Arduino board and in case of any discrepancy send a SMS notification as well as a notification on the application developed for the same to the farmer’s smartphone using Wi-Fi/3G/4G. The system has a duplex communication link based on a cellular- Internet interface that allows for data inspection and irrigation scheduling to be programmed through an android application. Because of its energy autonomy and low cost, the system has the potential to be useful in water limited geographically isolated areas.

Drawbacks:

- Sensors like moisture, temperature, humidity, motion etc. but not limited to only these.

5. Smart Drip Irrigation System for sustainable Agriculture

Kavianand G, Nivas V M, Kiruthika R, Lalitha S, Panimalar Engineering College, Chennai, India.

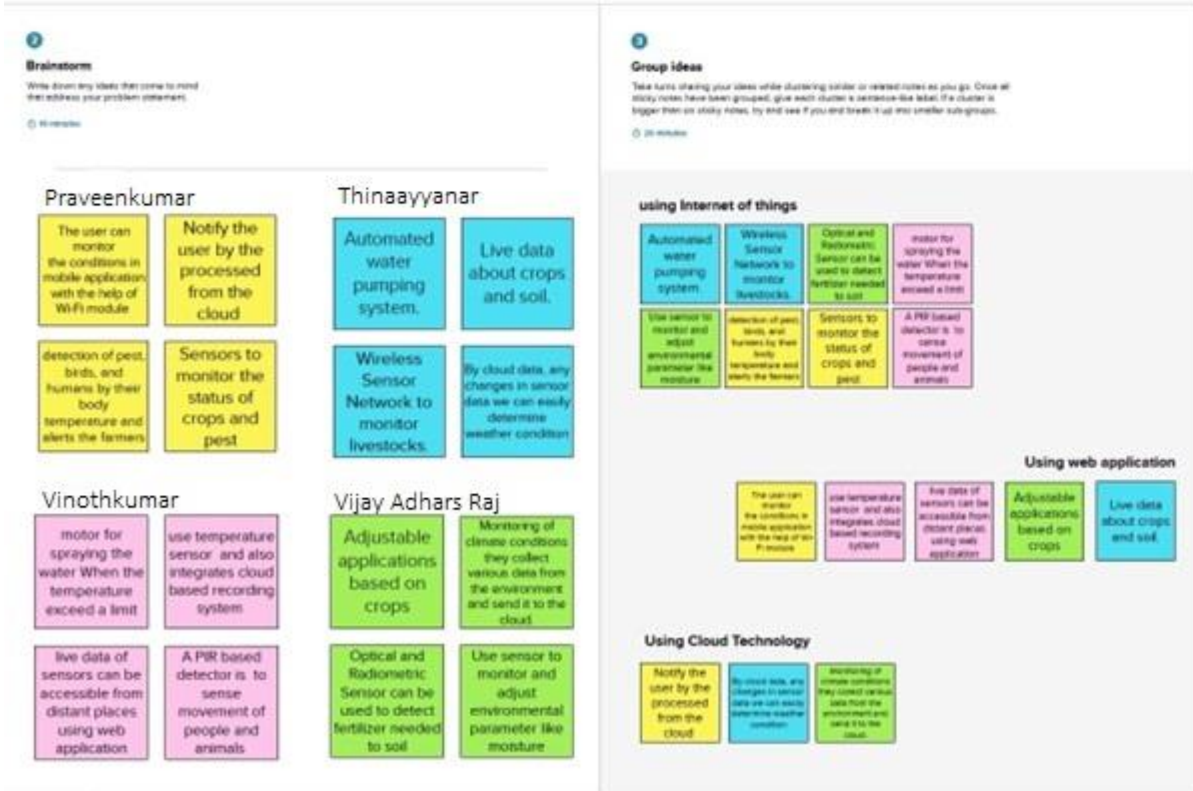
Agriculture is the back bone of India. To make the sustainable agriculture, this system is proposed. In this system ARM 9 processor is used to control and monitor the irrigation system. Different kinds of sensors are used. This paper presents a fully automated drip irrigation system which is controlled and monitored by using ARM9 processor.PH content and the nitrogen content of the soil are frequently monitored. For the purpose of monitoring and controlling, GSM module is implemented. The system informs user about any abnormal conditions like less moisture content and temperature rise, even concentration of CO_2 via SMS through the GSM module.

Drawbacks:

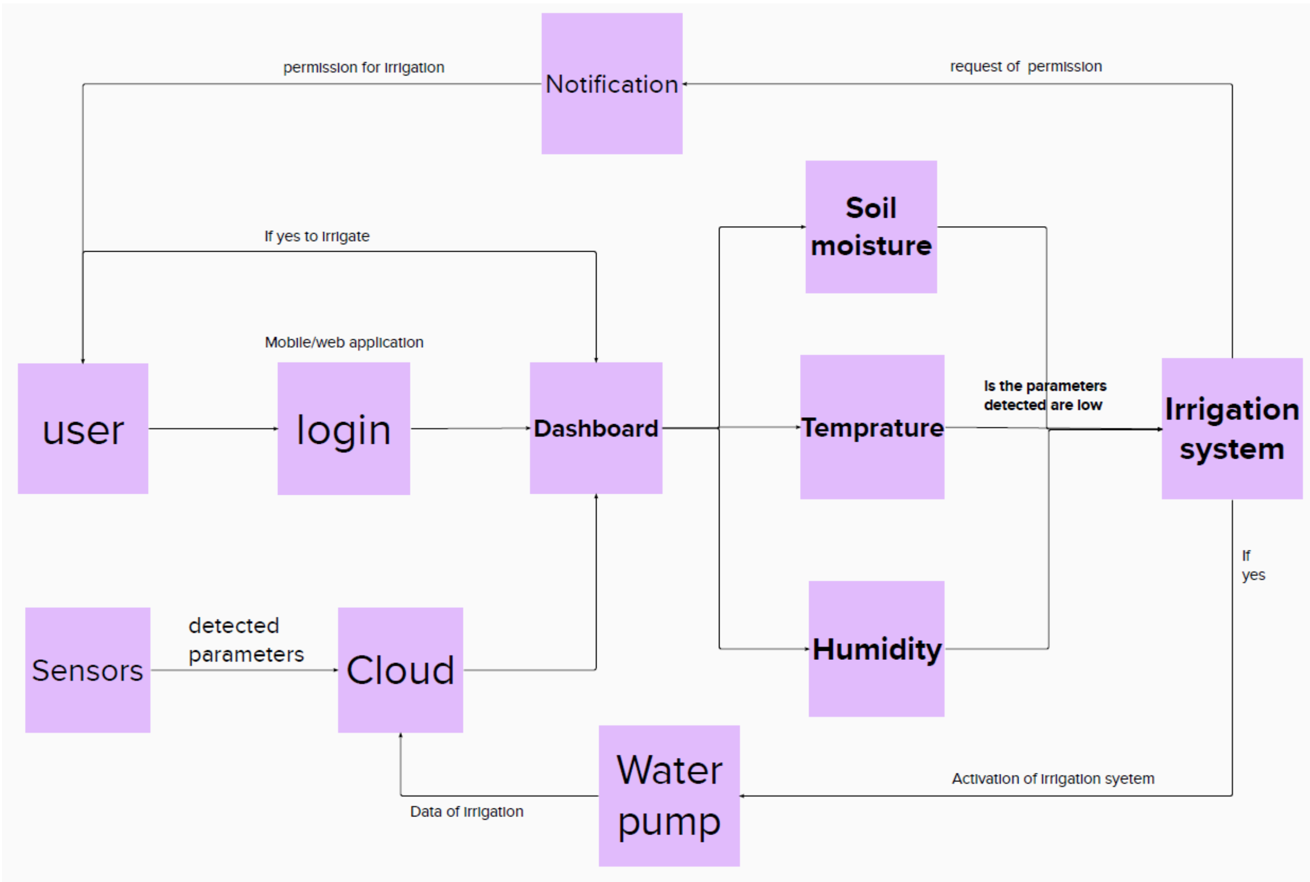
- The traditional irrigation methods are still predominant when it comes to try and correct the natural rain distribution

Empathy Map :


remote monitoring
reduced human labor
What do they
THINK AND FEEL?
what really counts
major preoccupations
worries & aspirations
easy pestify and fertilization
irrigation will be optimized
Farming will be managed by AI & IOT
less chemical interaction
What do they
HEAR?
what friends say
what boss say
what influencers say
regular monitoring
sensor monitoring
irrigation in timing
What do they
SEE?
environment
friends
what the market offers
perfect fertilization
reduced of water usage
will the ratio of fertilizer will be mixed accurately
can it notify when the corps are ready to harvest
What do they
SAY AND DO?
attitude in public
appearance
behavior towards others
can it give the accurate result in detections
whether it is suitable for every kind of crops
what will be the time of irrigation
can it detect the disease and pesticide
deteriorated soil quality
PAIN
fears
frustrations
obstacles
possibility of damage by animals
climate change
user friendly
GAIN
"wants" / needs
measures of success
obstacles
simple login
easy to access


Brainstorm
Group ideas
Praveenkumar
The user can monitor the conditions in mobile application with the help of Wi-Fi module
Notify the user by the processed from the cloud
detection of pest, birds, and humans by their body temperature and alerts the farmers
Sensors to monitor the status of crops and pest
Thinaayyanar
Automated water pumping system.
Live data about crops and soil.
Wireless Sensor Network to monitor livestocks.
By cloud data, any changes in sensor data we can easily determine weather condition
Vinothkumar
motor for spraying the water When the temperature exceed a limit
use temperature sensor and also integrates cloud based recording system
live data of sensors can be accessible from distant places using web application
A PIR based detector is to sense movement of people and animals
Vijay Adhars Raj
Adjustable applications based on crops
Monitoring of climate conditions they collect various data from the environment and send it to the cloud
Optical and Radiometric Sensor can be used to detect fertilizer needed to soil
Use sensor to monitor and adjust environmental parameter like moisture
using Internet of things
Using web application
Using Cloud Technology

CHAPTER 3



3.1EXISTING SYSTEM

- Manual checking of temperature, water and moisture of the farming lands.
- Detecting physical parameters by using sensors and operating pumps by using Bluetooth.
- The GSM based controlling of the Agricultural land pumps.
- Harmful pesticides used to control the insects.

3.2 DISADVANTAGES

- Challenges in Using Smart Technologies in Farming
- The Smart Agriculture Cost
- Possibility for wrong Analysis of Weather Conditions

3.3 PROPOSED SYSTEM

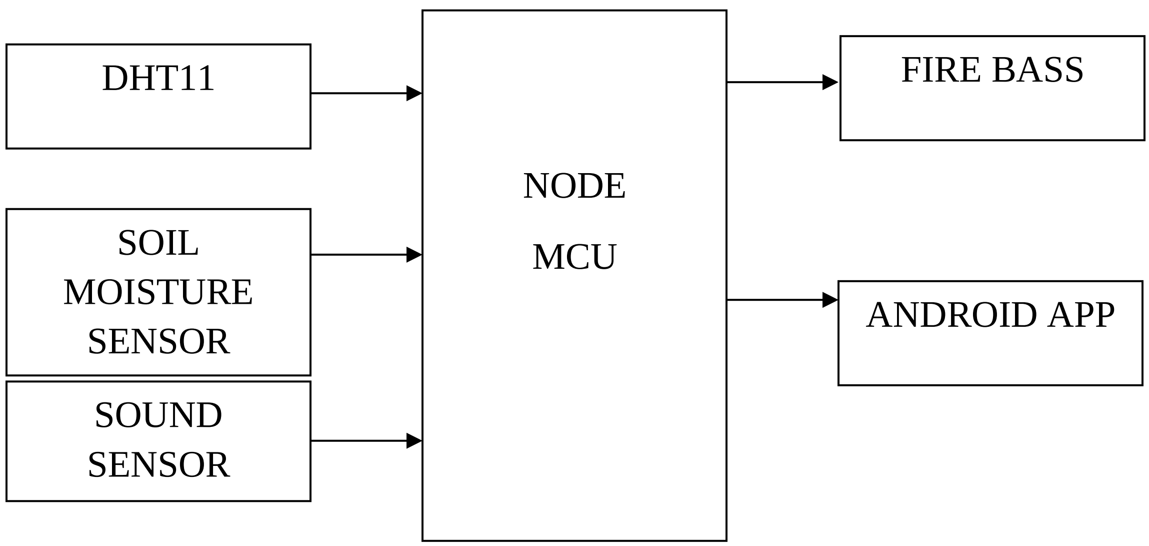
- I/O interface for Sensors.
- Interface for connecting to Internet.
- Interface for cloud server.
- Fully application controlled automated system.

3.4 ADVANTAGES

- Greenhouse is now automated by IoT in Agriculture
- The internet of Farm is an organisation that encourage precise agriculture
- Minimising water usage in Agriculture and Greenhouses
- Livestock Monitoring is more used than Ever
- Farmers can track pests and act using Wireless Technology

CHAPTER-4

METHODOLOGY



CHAPTER-5

HARDWARE DESCRIPTION

5.1 NODEMCU

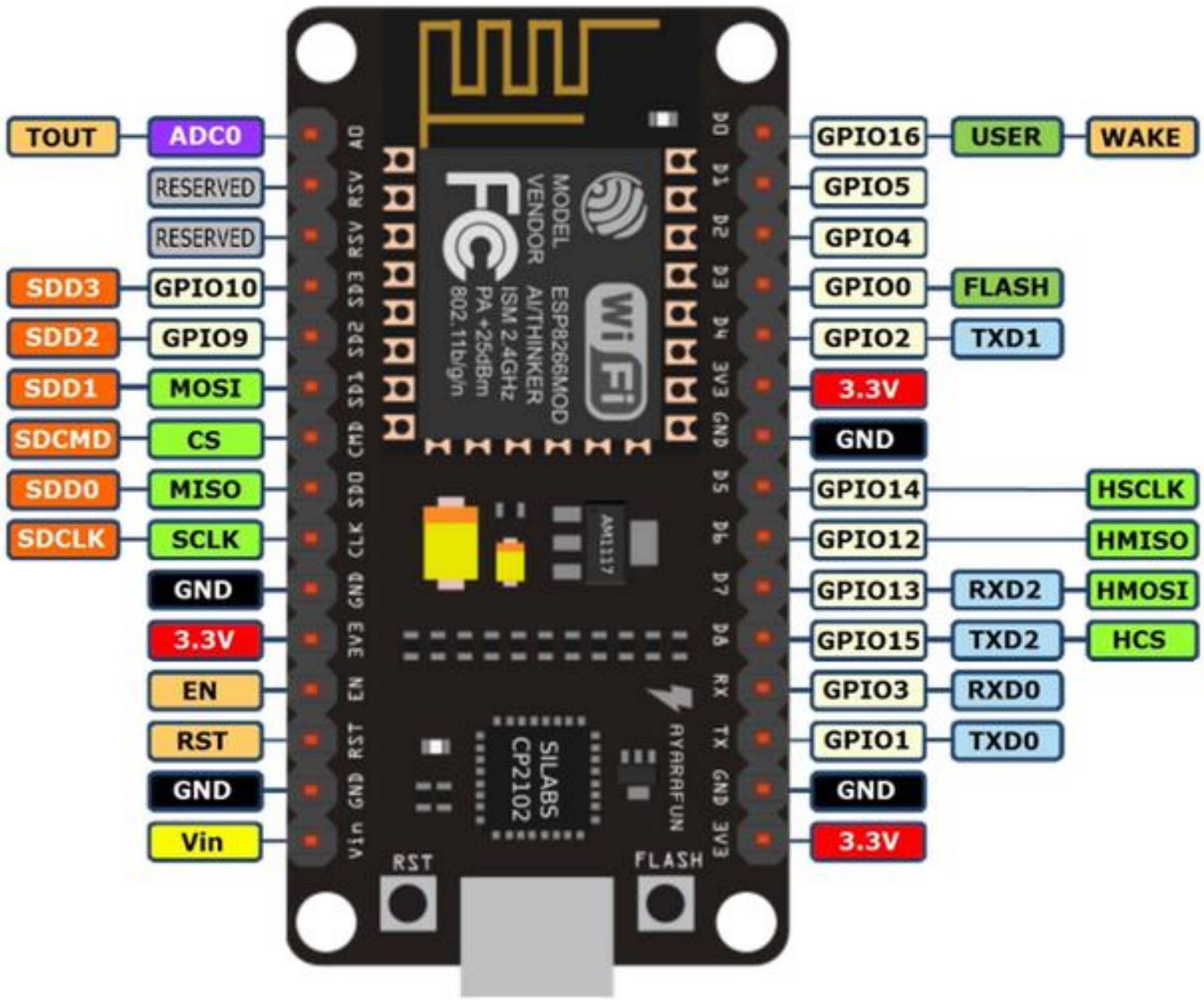
Express will make the ESP8266 arrangement, or family, of Wi-Fi chips Express. If Systems, a fables semiconductor organization working out for Shanghai, China, then the ESP8266 is incorporating the “ESP8285 and ESP8266EX chips”. ESP8266EX (essentially alluded to as ESP8266) is a framework on-chip (SoC) that incorporates a“32-bit Tensilica microcontroller”, standard sophisticated fringe interfaces, control intensifier, receiving wire switches, RFbalun, low disorder get enhancer, channels and power organization modules under a little bundle. It provides capacities to 2.4 GHz Wi-Fi (802. 11 b/g/n, supporting WPA/WPA2), simple tocomputerized transformation (10-bit ADC), mostly utilized information/yield (16 GPIO), I²S interfaces with DMA (offering pins to GPIO), Inter-Integrated circlet (I²C), serial peripheral interface (SPI), UART (on committed pins, as well to a transmit-no one but UART might be enabled on GPIO2), and heartbeat width tweak (PWM)

NodeMCU Dev Board is based on widely explored esp8266 System on Chip from Expressive. It combined features of WIFI access point and station + microcontroller and uses simple LUA based programming language. ESP8266 NodeMCU offers-

- Arduino-like hardware IO
- Event-driven API for network applications
- 10 GPIOs D0-D10, PWM functionality, IIC and SPI communication, 1-Wire and ADC A0 etc. all in one board
- Wi-Fi networking (can be uses as access point and/or station, host a webserver), connect to internet to fetch or upload data.
- excellent few $ system on board for Internet of Things (IoT) projects.

  NodeMCU is an eLua based firmware for the ESP8266 WiFi SOC from Espressif systems. The hardware is based on the ESP-12 module. The firmware is based on the Espressif NON-OS SDK 2.1.0 and uses a file system based on spiffs. The code repository consists of 98.1% C-code that glues the thin Lua veneer to the SDK. Asynchronous event-driven programming model.

•



• **FIG 5.1 NODE MCU PIN DIAGRAM**

While writing GPIO code on NodeMCU, you can’t address them with actual GPIO Pin Numbers. There are different I/O Index numbers assigned to each GPIO Pin which is used for GPIO Pin addressing. Refer following table to check I/O Index of NodeMCU GPIO Pins –

DHT11 Sensor

Humidity is the measure of water vapour present in the air. The level of humidity in air affects various physical, chemical and biological processes. In industrial applications, humidity can affect the business cost of the products, health and safety of the employees. So, in semiconductor industries and control system industries measurement of humidity is very important. Humidity measurement determines the amount of moisture present in the gas that can be a mixture of water vapour, nitrogen, argon or pure gas etc… Humidity sensors are of two types based on their measurement units. They are a relative humidity sensor and Absolute humidity sensor. DHT11 is a digital temperature and humidity sensor.

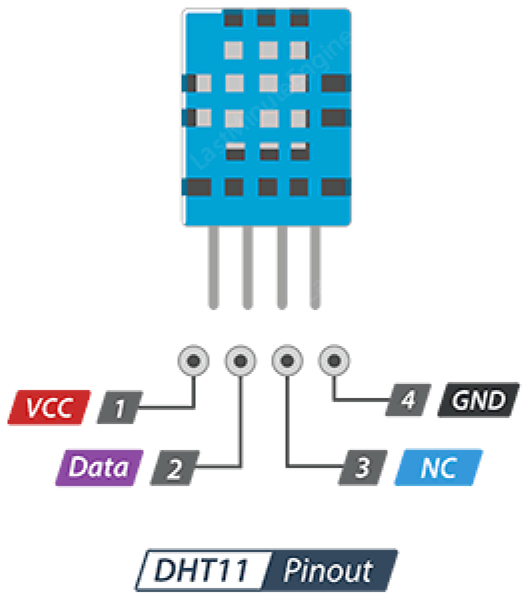
DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc… to measure humidity and temperature instantaneously.

DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor.

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers.

The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA.



SOIL MOISTURE SENSOR

Soil moisture sensors measure the water content in the soil and can be used to estimate the amount of stored water in the soil horizon. Soil moisture sensors do not measure water in the soil directly. Instead, they measure changes in some other soil property that is related to water content in a predictable way.

Another critical difference between soil moisture sensor types is the probe geometry and whether it measures a single point, multiple points, or continuously along the entire length of the probe. Point measurements are single-point soil moisture sensors, which means they measure a single location and depth.

Soil moisture profiling probes measure moisture content across a vertical soil profile, typically spanning a range of 30cm to 120cm. Most usually consist of multiple single-point sensors housed within an elongated enclosure; this type of geometry allows for several points to be installed quickly and at one time. However, the GroPoint Profile features modular segments that form a single antenna allowing for continuous measurements across the entire length, giving a true soil moisture profile.

The chief advantage of using a soil moisture profiling probe is the elimination of the cost of multiple single-point sensors and the need to excavate and bury them at the appropriate depths. To install most profiling probes, either plastic or PVC access tubes need to be inserted before the sensor can be. This design imposes uncertainties, and in some cases, there tends to be a preferential flow between the access tube and the sensor. Soil moisture probes like the GroPoint Profile, which don't require an access tube, will typically provide greater accuracy for this reason.

Depending on whether the soil moisture sensor you choose is a point measurement or a true profiling soil sensor like the GroPoint Profile, it is essential to know that the readings will be different when placed at the same depth and location. The Point Probe will give measurements at a specific depth, where the GroPoint Profile averages the moisture content over each segment of the probe, making it less susceptible to inconsistencies in the soil. Click through the below images for more information.

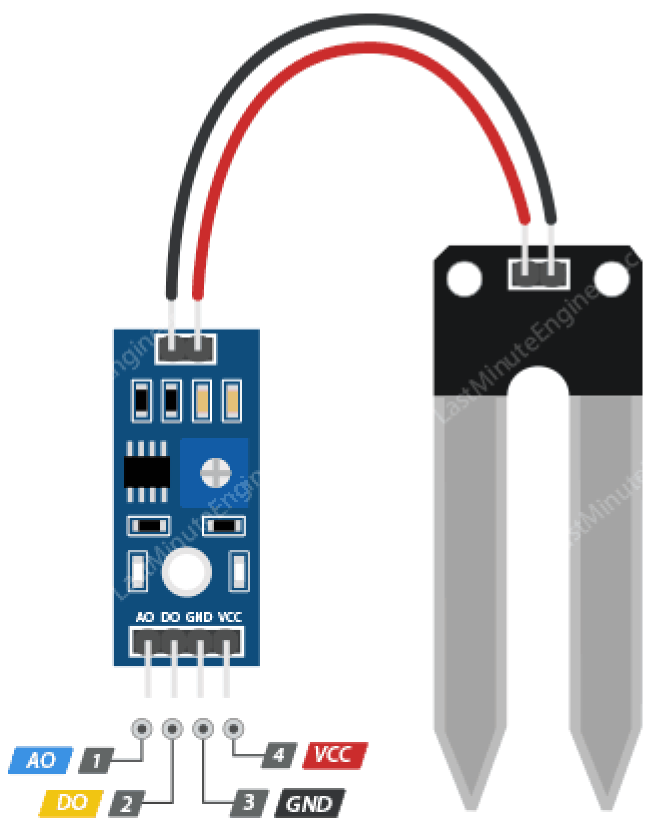


FIG 5.3 SOIL MOISTURE SENSOR PINOUT

SOUND SENSOR

Basically, Sound is a waveform of energy which is produced by the form of mechanical vibration. The type of sound determines its frequency. For example, a bass drum has a low-frequency sound and a cymbal has a higher frequency sound. The sound sensor is a simple device which can detect the sound. The sound sensors are very simple to use.

Pin Configuration and Components

The sound sensor consist of Microphone as a transducer, potentionmeter to adjust the intensity, LM386 low power audio amlifier, LED and other passive components like resistors and capacitors.

You can set a threshold value using a potentiometer so that when the amplitude of the sound exceeds the threshold value, the module will output LOW otherwise HIGH.

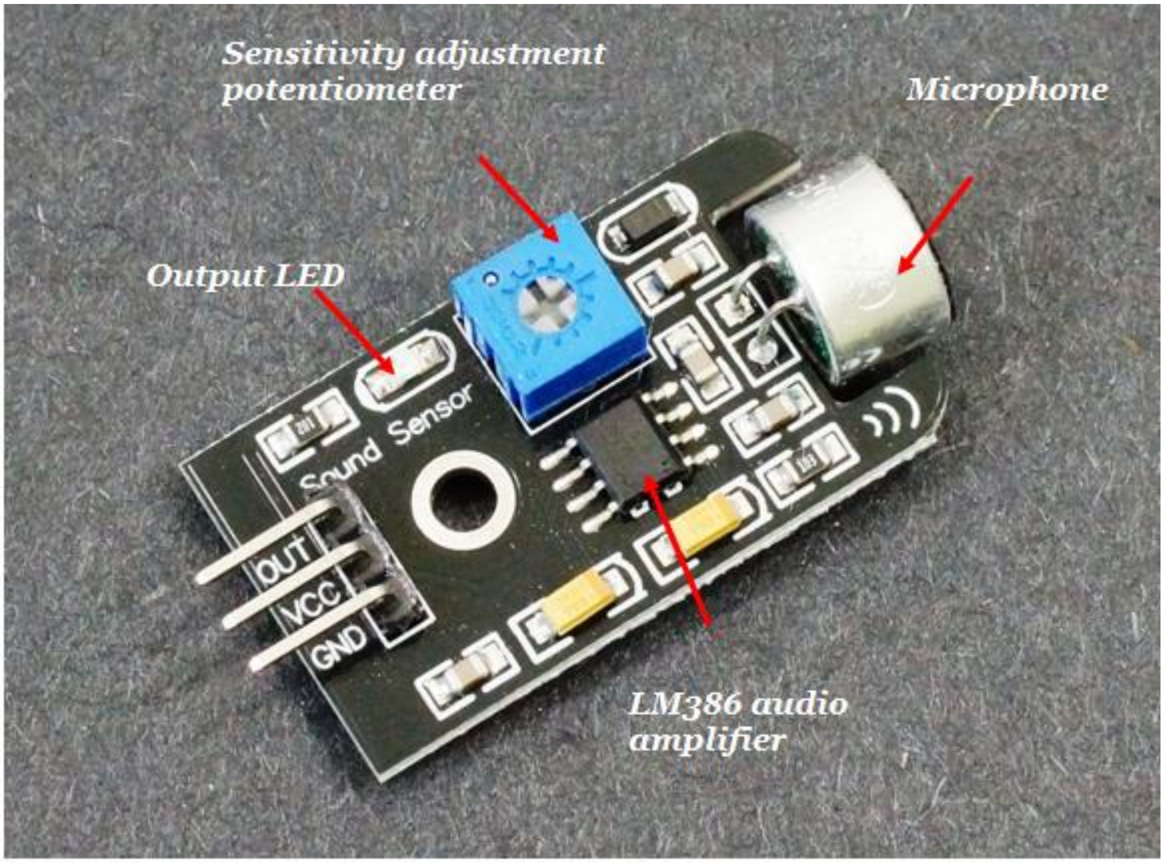


FIG 5.4 SOUND SENSOR PINOUT

This sensor includes 3 pins and they are,

Pin1 (VCC): 3.3V DC to 5V DC

Pin2 (GND): This is aground pin

Pin3 (OUT): This is an output pin. It provides high signal when there is no sound and goes LOW when sound is detected. You can connect it to any digital pin on an Arduino or directly to a 5V relay or similar device.

Working Principle of Sound Sensor

It works similar to our ears. Our Ears have a diaphragm which converts the detected the vibration and converts it in the signal. Similarly, the sound sensors convert the vibration into audio signal (voltage and current proportional) with the help of a microphone.

This microphone has an inbuilt diaphragm, made up of magnets which are coiled by metal wire. Whenever sound waves hits the diaphragm, magnets vibrate and at the same time coil induces the current.

CHAPTER-6
SOFTWARE DESCRIPTION

Embedded C

An embedded system is an application that contains at least one programmable computer (typically in the form of a microcontroller, a microprocessor or digital signal processor chip) and which is used by individuals who are, in the main, unaware that the system is computer-based.

Introduction

Looking around, we find ourselves to be surrounded by various types of embedded systems. Be it a digital camera or a mobile phone or a washing machine, all of them has some kind of processor functioning inside it. Associated with each processor is the embedded software. If hardware forms the body of an embedded system, embedded processor acts as the brain, and embedded software forms its soul. It is the embedded software which primarily governs the functioning of embedded systems.

During infancy years of microprocessor based systems, programs were developed using assemblers and fused into the EPROMs. There used to be no mechanism to find what the program was doing. LEDs, switches, etc. were used to check correct execution of the program. Some ‘very fortunate’ developers had In-circuit Simulators (ICEs), but they were too costly and were not quite reliable as well.

As time progressed, use of microprocessor-specific assembly only as the programming language reduced and embedded systems moved onto C as the embedded programming language of choice. C is the most widely used programming language for embedded processors/controllers. Assembly is also used but mainly to implement those portions of the code where very high timing accuracy, code size efficiency, etc.

are prime requirements.

Initially C was developed by Kernighan and Ritchie to fit into the space of 8K and to write (portable) operating systems. Originally it was implemented on UNIX operating systems. As it was intended for operating systems development, it can manipulate memory addresses. Also, it allowed programmers to write very compact codes. This has given it the reputation as the language of choice for hackers too.

As assembly language programs are specific to a processor, assembly language didn't offer portability across systems. To overcome this disadvantage, several high-level languages, including C, came up. Some other languages like PLM, Modula-2, Pascal, etc. also came but couldn't find wide acceptance. Amongst those, C got wide acceptance for not only embedded systems, but also for desktop applications. Even though C might have lost its sheen as mainstream language for general purpose applications, it still is having a strong-hold in embedded programming. Due to the wide acceptance of C in the embedded systems, various kinds of support tools like compilers & cross-compilers, ICE, etc. came up and all this facilitated development of embedded systems using C. Subsequent sections will discuss what is Embedded C, features of C language, similarities and difference between C and embedded C, and features of embedded C programming.

EMBEDDED SYSTEMS PROGRAMMING

Embedded systems programming is different from developing applications on a desktop computers. Key characteristics of an embedded system, when compared to PCs, are as follows. Embedded devices have resource constraints(limited ROM, limited RAM, limited stack space, less processing power) Components used in embedded system and PCs are different; embedded systems typically uses smaller, less power consuming components. Embedded systems are more tied to the hardware. Two salient features of Embedded Programming are code speed and code size. Code speed is governed by the processing power, timing constraints, whereas code size is governed by available program memory and use of programming language. Goal of embedded system programming is to get maximum features in minimum space and minimum time.

Embedded systems are programmed using different type of language

- Machine Code
- Low level language, i.e., assembly
- High level language like C, C++, Java, Ada, etc.
- Application level language like Visual Basic, scripts, Access, etc.

Assembly language maps mnemonic words with the binary machine codes that the processor uses to code the instructions. Assembly language seems to be an obvious choice for programming embedded devices. However, use of assembly language is restricted to developing efficient codes in terms of size and speed. Also, assembly codes lead to higher software development costs and code portability is not there. Developing small codes are not much of a problem, but large programs/projects become increasingly difficult to manage in assembly language. Finding good assembly programmers has also become difficult nowadays. Hence high level languages are preferred for embedded systems programming.

Use of C in embedded systems is driven by following advantages it is small and reasonably simpler to learn, understand, program and debug. C Compilers are available for almost all embedded devices in use today, and there is a large pool of experienced C programmers.

Unlike assembly, C has advantage of processor-independence and is not specific to any particular microprocessor/ microcontroller or any system. This makes it convenient for a user to develop programs that can run on most of the systems. As C combines functionality of assembly language and features of high level languages, C is treated as a 'middle-level computer language' or 'high level assembly language'. It is fairly efficient. It supports access to I/O and provides ease of management of large embedded projects.

Many of these advantages are offered by other languages also, but what sets C apart from others like Pascal, FORTRAN, etc. is the fact that it is a middle level language; it provides direct hardware control without sacrificing benefits of high level languages. Compared to other high level languages, C offers more flexibility because C is relatively small, structured language; it supports low-level bit-wise data manipulation. Compared to assembly language, C Code written is more reliable and scalable, more portable between different platforms (with some changes). Moreover, programs developed in C are much easier to understand, maintain and debug. Also, as they can be developed more quickly, codes written in C offers better productivity. C is based on the philosophy ‘programmers know what they are doing’; only the intentions are to be stated explicitly. It is easier to write good code in C & convert it to an efficient assembly code (using high quality compilers) rather than writing an efficient code in assembly itself. Benefits of assembly language programming over C are negligible when we compare the ease with which C programs are developed by programmers. Objected oriented language, C++ is not apt for developing efficient programs in resource constrained environments like embedded devices. Virtual functions & exception handling of C++ are some specific features that are not efficient in terms of space and speed in embedded systems. Sometimes C++ is used only with very few features, very much as C. Ada, also an object-oriented language, is different than C++. Originally designed by the U.S. DOD, it didn’t gain popularity despite being accepted as an international standard twice (Ada83 and Ada95). However, Ada language has many features that would simplify embedded software development.

Java is another language used for embedded systems programming. It primarily finds usage in high-end mobile phones as it offers portability across systems and is also useful for browsing applications. Java programs require Java Virtual Machine (JVM), which consume lot of resources. Hence it is not used for smaller embedded devices. Dynamic C and B# are some proprietary languages which are also being used in embedded applications. Efficient embedded C programs must be kept small and efficient; they must be optimized for code speed and code size. Good understanding of processor architecture embedded C programming and debugging tools facilitate this.

Difference between C and embedded C:

Though C and embedded C appear different and are used in different contexts, they have more similarities than the differences. Most of the constructs are same; the difference lies in their applications.

C is used for desktop computers, while embedded C is for microcontroller based applications. Accordingly, C has the luxury to use resources of a desktop PC like memory, OS, etc. While programming on desktop systems, we need not bother about

memory. However, embedded C has to use with the limited resources (RAM, ROM, I/Os) on an embedded processor. Thus, program code must fit into the available program memory. If code exceeds the limit, the system is likely to crash. Compilers for C (ANSI C) typically generate OS dependant executables. Embedded C requires compilers to create files to be downloaded to the microcontrollers/microprocessors where it needs to run. Embedded compilers give access to all resources which is not provided in compilers for desktop computer applications. Embedded systems often have the real-time constraints, which is usually not there with desktop computer applications.

Embedded systems often do not have a console, which is available in case of desktop applications. So, what basically is different while programming with embedded C is the mindset; for embedded applications, we need to optimally use the resources, make the program code efficient, and satisfy real time constraints, if any. All this is done using the basic constructs, syntaxes, and function libraries of 'C'.

Keil C51 C Compilers

- Direct C51 to generate a listing file
- Define manifest constants on the command line
- Control the amount of information included in the object file

- Specify the level of optimization to use
- Specify the memory models

Specify the memory space for variables The Keil C51 C Compiler for the 8051 microcontroller is the most popular 8051 C compiler in the world. It provides more features than any other 8051 C compiler available today.

The C51 Compiler allows you to write 8051 microcontroller applications in C that, once compiled, have the efficiency and speed of assembly language. Language extensions in the C51 Compiler give you full access to all resources of the 8051.

The C51 Compiler translates C source files into reloadable object modules which contain full symbolic information for debugging with the µVision Debugger or an in- circuit emulator. In addition to the object file, the compiler generates a listing file which may optionally include symbol table and cross reference information.

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CODE:

```
// Comment this out to disable prints and save space
#include <SPI.h>
#include <DHT.h>
#include <ESP8266WiFi.h>
#include <FirebaseESP8266.h>
#define FIREBASE_HOST "agriiot-odugaa-jana-default-rtdb.firebaseio.com"
#define FIREBASE_AUTH "7SvKj7VemWgek22yXN9ASqWeWrHHIx376TWHFDZ2"
//Your Firebase Database Secret goes here
#define WIFI_SSID "Odugaa"                                  //WiFi SSID to which you want
NodeMCU to connect
#define WIFI_PASSWORD "Odugaatech@123"                                //Password of your
wifi network
// Declare the Firebase Data object in the global scope
FirebaseData firebaseData;

// Declare global variable to store value
int val = 0;
int analogPin = A0; // potentiometer wiper (middle terminal) connected to analog pin 3
// outside leads to ground and +5V
int soilval = 0;  // variable to store the value read

void soil() ;

int soundPin = D3;    // pushbutton connected to digital pin 7
```

```
int soundval = 0;      // variable to store the read value

void soundfun();




//#define DHTPIN 14          // Digital pin 4
int DHTPIN = D2;
//#define Fan D6



#define DHTTYPE DHT11     // DHT 11

DHT dht(DHTPIN, DHTTYPE);
//SimpleTimer timer;
void sendSensor()
{
  float h = dht.readHumidity();
  float t = dht.readTemperature(); // or dht.readTemperature(true) for Fahrenheit

  if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }
  // You can send any value at any time.
  // Please don't send more that 10 values per second.

  Serial.print("temp :");
```

```
  Serial.println(t);

  Serial.println("humi:");
  Serial.println(h);

  //  if(Firebase.setInt(firebaseData, "/Data/led/temp", t )){
  //    Serial.println(" connect to tmp send ");
  //  }else{
  //    Serial.println(" connect failed tmp");
  //  }
  Firebase.setInt(firebaseData, "/Data/led/humi", h );
  Firebase.setInt(firebaseData, "/Data/led/temp", t );

  //  if(t>=34){
  //     //digitalWrite(Fan, HIGH);
  //  }
  //  else{
  //     //digitalWrite(Fan, LOW);
  //  }
}
// pinMode(Fan,OUTPUT);

// Setup a function to be called every second
//  timer.setInterval(100L, sendSensor);
//delay(2000);

void soil()
{
```

```
  soilval = analogRead(analogPin);  // read the input pin
  Serial.println(soilval);          // debug value
  Firebase.setInt(firebaseData, "/Data/led/soilval", soilval  );
}

void soundfun()
{
  soundval = digitalRead(soundPin);   // read the input pin
  Serial.println( soundval);
  Firebase.setInt(firebaseData, "/Data/led/soundval", soundval);
}




void setup()
{
  Serial.begin(115200);
  dht.begin();

  Serial.println("Serial communication started\n\n");

  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);                                  //try to connect with
wifi
  Serial.print("Connecting to ");
  Serial.print(WIFI_SSID);
```

```
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }



  Serial.println();
  Serial.print("Connected to ");
  Serial.println(WIFI_SSID);
  Serial.print("IP Address is : ");
  Serial.println(WiFi.localIP());                                    //print local IP address
  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);   // connect to firebase

  Firebase.reconnectWiFi(true);
  delay(1000);
}




void loop()
{
  Serial.print("hi");
  sendSensor();
  soil() ;
  soundfun();
```

```
  //    if (Firebase.setInt(firebaseData, "/Data/led/value",  val)) {    // On successful Write operation, function returns 1

  //                Serial.println("Value Uploaded Successfully");

  //                Serial.print("Val = ");

  //                Serial.println(val);

  //                Serial.println("\n");

  //

  //                val++;

  //                delay(100);

  //

  //        }

  //

  //  else {

  //      Serial.println(firebaseData.errorReason());

  //

  //    }



  //  timer.run(); // Initiates SimpleTimer

}
```

ANDROID

Android is an open source and Linux-based Operating System for mobile devices such as smartphones and tablet computers. Android was developed by the Open Handset Alliance, led by Google, and other companies.

Android offers a unified approach to application development for mobile devices which means developers need only develop for Android, and their applications should be able to run on different devices powered by Android.

The first beta version of the Android Software Development Kit (SDK) was released by Google in 2007 where as the first commercial version, Android 1.0, was released in September 2008.

On June 27, 2012, at the Google I/O conference, Google announced the next Android version, 4.1 Jelly Bean. Jelly Bean is an incremental update, with the primary aim of improving the user interface, both in terms of functionality and performance.

The source code for Android is available under free and open source software licenses. Google publishes most of the code under the Apache License version 2.0 and the rest, Linux kernel changes, under the GNU General Public License version 2.

Features of Android

Android is a powerful operating system competing with Apple 4GS and supports great features.

Sr.No.	Feature & Description
1	**Beautiful UI** Android OS basic screen provides a beautiful and intuitive user interface.

2	**Connectivity** GSM/EDGE, IDEN, CDMA, EV-DO, UMTS, Bluetooth, Wi-Fi, LTE, NFC and WiMAX.
3	**Storage** SQLite, a lightweight relational database, is used for data storage purposes.
4	**Media support** H.263, H.264, MPEG-4 SP, AMR, AMR-WB, AAC, HE-AAC, AAC 5.1, MP3, MIDI, Ogg Vorbis, WAV, JPEG, PNG, GIF, and BMP.
5	**Messaging** SMS and MMS
6	**Web browser** Based on the open-source WebKit layout engine, coupled with Chrome's V8 JavaScript engine supporting HTML5 and CSS3.
7	**Multi-touch** Android has native support for multi-touch which was initially made available in handsets such as the HTC Hero.
8	**Multi-tasking** User can jump from one task to another and same time various application can run simultaneously.
9	**Resizable widgets** Widgets are resizable, so users can expand them to show more content or shrink them to save space.
10	**Multi-Language** Supports single direction and bi-directional text.

11	**GCM** Google Cloud Messaging (GCM) is a service that lets developers send short message data to their users on Android devices, without needing a proprietary sync solution.
12	**Wi-Fi Direct** A technology that lets apps discover and pair directly, over a high-bandwidth peer-to-peer connection.
13	**Android Beam** A popular NFC-based technology that lets users instantly share, just by touching two NFC-enabled phones together.

Android Applications

Android applications are usually developed in the Java language using the Android Software Development Kit.

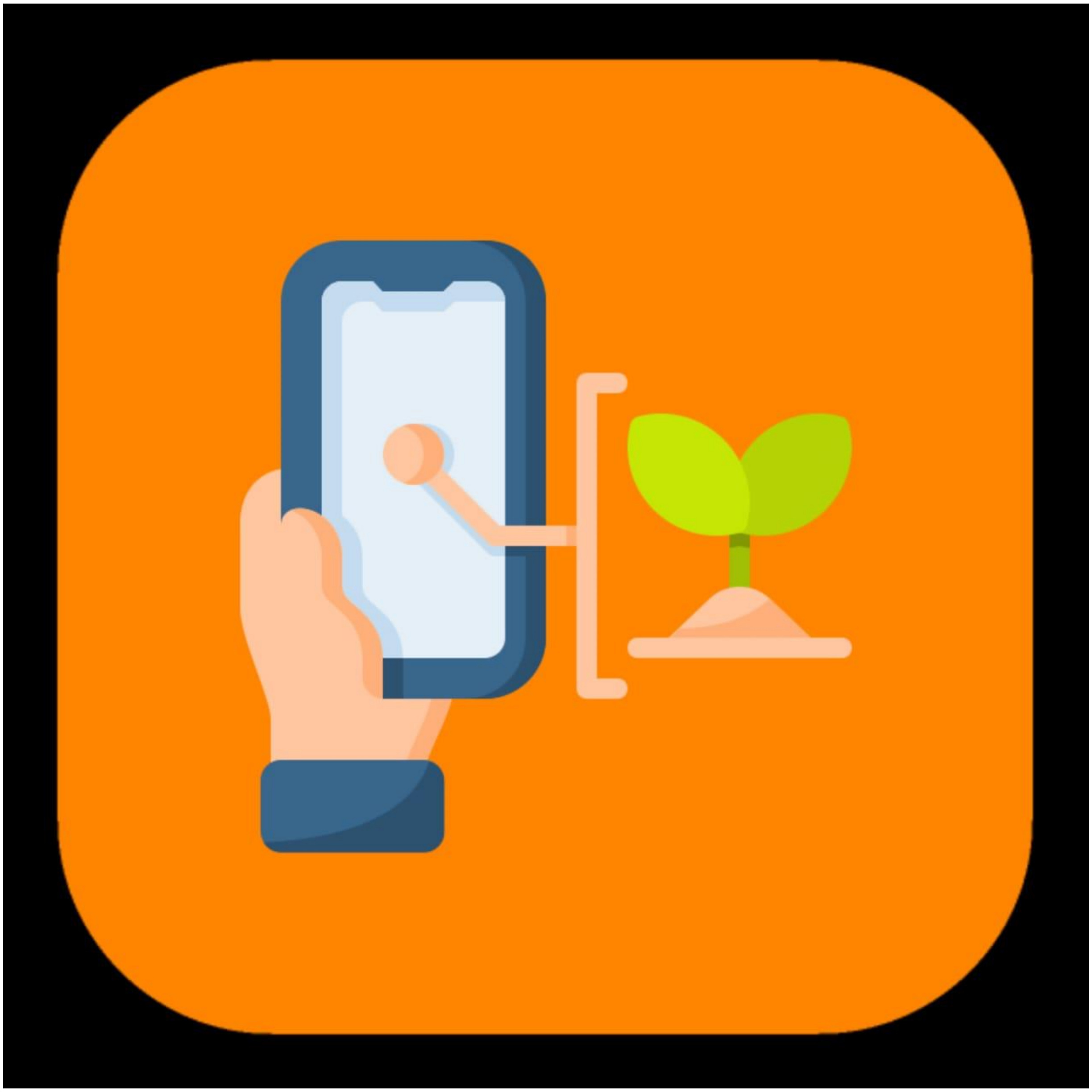
Once developed, Android applications can be packaged easily and sold out either through a store such as Google Play, SlideME, Opera Mobile Store, Mobango, F-droid and the Amazon Appstore.

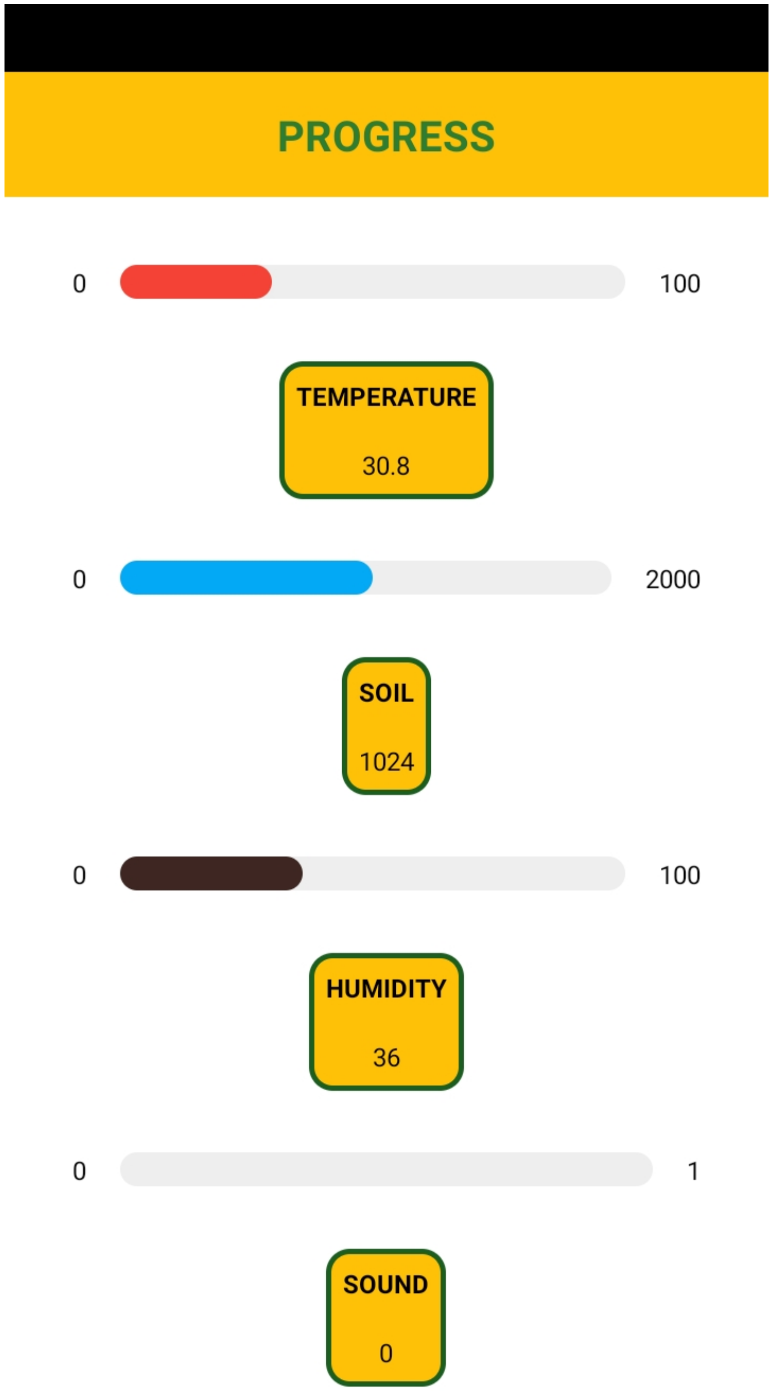
Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It's the largest installed base of any mobile platform and growing fast. Every day more than 1 million new Android devices are activated worldwide.

This tutorial has been written with an aim to teach you how to develop and package Android application. We will start from environment setup for Android application programming and then drill down to look into various aspects of Android applications.

CHAPTER-7

WORKING IMAGES




PROGRESS
0
100
TEMPERATURE
30.8
0
2000
SOIL
1024
0
100
HUMIDITY
36
0
1
SOUND
0

CHAPTER-8

8.1 CONCLUSION

Farming can be made more efficient & accurate with the implementation of like this prediction based IoT device. IoT can be used in different domains of agriculture. Electricity and water are the main domains and their cost can improve or break the agriculture profession. Because of old leaky irrigation system water wastage is a way more than we think and water pump operates by using electricity so if we can control water wastage then we are automatically controlling electricity wastage also. Water volume can be controlled by using a smartphone with pump. Other domains in agriculture are insecticide, fertilizers and pesticides as in this paper we are proposing use of piezo electric sensor and piezo electric sensor can generate the frequency of wings speed of *Dragon fly* so there is almost outside factors like insects do not enter and cannot harm the crop so there will be less/no need of insecticides. By using camera sensor age prediction the crop in the field that is connected to internet, an appropriate decision can be taken regarding water supply. Finally conclude that we need to develop and optimal IoT architecture for agriculture in order to enhance quality and quantity of production, save resources like water and electricity, economically efficient crop that cost less and make more profit as in country like India farmers play a major role in GDP so this way the overall GDP can also be enhanced.

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