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Enable Smart Farm in Digital India with Artificial Intelligence and IoT

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Abstract*: Agriculture in India being the major source of living for about 70% of the total rural population. Although it is contributing around 14% of total GDP but the average annual family income of farmers is less than 70K INR. The scarcity & increasing labour costs, raising cost of cultivation and crop failures associated with unpredictable yield due to diseases, failure in rainfall, climatic variations and loss of soil fertility, fluctuating market price in agriculture commodities etc., has made significant negative impact on the socio-economic status on this backbone population. On the other side the raise in population has created more demand on food grains resulting with inflation in agriculture commodity prices. Meanwhile, the today's technology advancement in Artificial Intelligence, Big Data, IoT are becoming the major drivers for providing the Digital IT solution almost in all the fields and business sectors. Hence, it is proposed to make use of Digital solution aided with Artificial intelligence to uplift the habitat of the trampled farmer community while providing yet a new opportunity for business and entrepreneurs by enabling smart farm as a service.*

Introduction

In the last several years, agriculture in India has become the last preferred occupation for new generation people even in the rural areas. There can be several reasons behind this pessimistic trend although more than 70% population in rural areas are still dependent on it. The major factors for this concern is unpredictable environmental changes in rainfall, soil erosion, scarcity of human laborers with increased cost, yield loss due to pests and insects, increase in cultivation cost, poor supply chain management & middle man brokerage resulting in market fluctuation. All these factors have pushed the farmer's life with agriculture as an occupation of gamble without any guarantee on ROI on the hard efforts spent throughout the year. Although there are various benefiting government policies and schemes like subsidies, crop insurance, promotional purchase price for agriculture commodities to safe guard farmers but still many farmer's income in India is hovering around poverty line only!

Hence by making use of Artificial Intelligence, Big data, IoT technologies in a closed loop control system as a Digital solution can be developed to enable smart farming. Today, we see a big gap in the rate at which the Information Technology is growing and its effective utilization in the agriculture sector in India. We can get a large amount of statistical data related to agriculture that are available both on government and public websites. And, also with the advancement of IoT, it is possible to sample the real-time data and status almost everywhere and on anything. This data can be fed to an Analytics platform engine making use of Artificial Intelligence, Machine Learning, Natural Language Processing and thereby create a Digital Solution to aid the farmers for addressing all the uncertain issues faced by farmers in the agriculture sector. The proposed approach explains the usage of open source tools and architecture there by making it as a cost-effective solution. And thus, offers an affordable *Smart Farm as service* for both the consumer and the service provider.

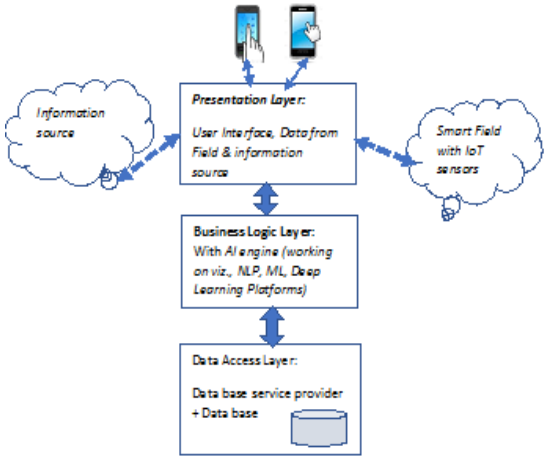
1. Enable Smart Farm as a Service

The complete Digital eco system to *Enable Smart Farm as a Service* can be built on a Service Oriented Architecture meta model. This model not only can help the farmer but also provides a business opportunity to service providers like entrepreneur, government authorized NGOs to develop, operate and maintain the system. The service consumers are the smart farmers who are going to benefit out of this end-to-end service in the agriculture farming activities.

2. Smart Farm Service Architecture

The proposed solution can be implemented by using Service Oriented Architecture pattern. The core of this SOA meta model can be built with 3-Tier Architecture with (i) Presentation layer for user

interface (ii) Business Logic layer powered with Artificial Intelligence making use of Natural Language Processing, Machine learning and deep learning techniques. (iii) The data base service provider connects the Business Logic Layer with database to Store, Modify and Retrieve information from Database. The presentation layer interacts with Information sources, smart field IoT sensors and as user interface through various access points for smart farmer



2.1. Smart Farm Service Architecture

3. Information Source for Service Provider

The authenticated sources of information needed on weather forecasts, irrigation resources data, fertilizers, agriculture equipment, agriculture market survey, government policies and all other necessary information for this system can be obtained from these government websites like http://agricoop.nic.in and http://agriculture.gov.in, http://farmer.gov.in, hosted by the Ministry of Agriculture and Farmers Welfare for the information on government schemes, guidance, policies. And http://agmarknet.gov.in provides the complete information and data on agriculture market network and related current affairs.
https://india.gov.in/topics/agriculture/irrigation for the details on irrigation and water supply for agriculture, http://fert.nic.in for the information on fertilizers and pesticides, http://www.imd.gov.in/ for the information on weather and rainfall.

4. Smart Field IoT sensors

The IoT enabled sensors need to be installed in the field at the prescribed locations. These sensors are the transducers that collect the data on climatic condition soil moisture & fertility, root & shoot growth, profused leaves growth, photo-period monitoring, floral & seed setting, grain/fruit bearing, pest & deceases as critical growth factors symptoms, harvest readiness.

The IOT device includes the transducer that probes the various parameters of environment and crop mentioned above. It can be mounted on protected mini board with WiFi device, microcontroller, low cost VGA image sensor, mini battery powered with micro solar panel. The data can be collected at required time intervals either by installing WiFi active hot spot towers as required for entire field coverage. Alternatively, drones with active WiFi hot spot can also be used to scan and collect data from IoT devices as well as to capture elevated motion picture of the entire field.

5. Smart Farm Analytics Engine powered by Artificial Intelligence

Analytics Engine is powered with Artificial Intelligence and serves as backbone for analytics and management center. The AI engine is to be built with NLP/NLU for chat bots, Machine learning for processing of big data sampled from various information sources and IoT devices.

5.1. NLP/NLU:

Natural Language Processing (NLP)/ Natural Language Understanding (NLU) is the primary element to drive bot technology. The NLP & NLU mainly focuses on signal processing, syntactic analysis, discourse analysis semantic analysis, pragmatics thereby enabling the Natural Language Generation for more meaningful conversation with context sensitive. Some of the popular enterprise platform that can be availed are IBM's Watson Conversation Service, Google Natural Language API, Microsoft LUIS, Wit.ai, Api.ai etc., As an alternate the following open source platform viz, Stanford's Core NLP Suite, Natural Language Toolkit, Apache Lucene and Solr, Apache OpenNLP, etc., can also be used.

5.2. Analytics & Machine Learning:

The complex set of data collected from the IoT sensors and other Information sources need to be processed through Analytics engine powered with machine Learning techniques. The machine learning is required to power up the Analytics engine at one side and on the other side it guides the chatbot and PID closed loop feedback controller.

The processing of data through Analytics engine can be realized by these popular machine learning techniques (i) Supervised learning where(x) and an output variable (Y) and you use an algorithm to learn

the mapping function from the input to the output. Y = f(X).

(ii) Unsupervised learning is where we only have input data (X) and no corresponding output variables.

The goal for unsupervised learning is to model the underlying structure or distribution in the data in order to learn more about the data. The objective is to approximate the mapping function so that for any new input data (x) we can predict the output variables (Y) for that data.

(iii) Reinforcement Learning allows machines and software agents to automatically determine the ideal behavior within a specific context, to maximize the performance. A reward feedback called as reinforcement signal is used as agent to learn the behavior of system.

The closed loop control feedback to the smart famers need to be processed through a PID (Proportional, Integral and Differential) controller. The PID controllers are driven with prediction and decision made by above listed machine learning processes. The proportional part ensures in providing a linear offset correction and acts as governor to keep the health of crop in constant pace. The Integral correction is immune to sudden changes happening on daily basis but provides a long term corrective measure by extrapolating the data collected at larger periodic samples. The differential controller feedback part provides immediate/priority action item to be taken by the farmers that can serious effect the crop if unattended on daily basis.

6. Smart Farm Service Access points

To enable the smart farm service the user can register to avail the service over a simple access point like Android smart phone with a supporting application to be developed for this purpose. The service can be made available and accessible with other platforms also for the addressing the extensibility and scalability. For providing a low-cost service the need of paid internet connectivity is not essential on these smartphones held by the farmers. Through the tie up with Internet Service Providers a toll free net access to this smart famer server can be achieved to avoid the need of any paid data packs for accessing this service.

7. Farmer Tariff Model as Service Consumer

The beneficiary of this service can be offered with following service models. (a) Chatbot (b) Agri-E-calculator for suitable crop selection along with resource estimation (c) Crop care service. (d) Price prediction and market guidance

(e) Crop loan and insurance service.

7.1. Chatbot

This service lets the farmer to get their queries answered via interactive voice chat in their native languages. The chatbot engine is driven with both supervised and reinforced machine learning techniques for a continuous and context sensitive learning. Thereby the chatbot answers to most of the generic queries before it lets to human operator intervention for any queries that are unique in nature.

7.2. Agri-E-Calculator

The *agri-e-calculator* as a smart application help the smart farmer to choose the most suitable crop and affordability based on several dependency factors. The farmer can use the smart calculator and just choose the desired crop to be cultivated over his preferred coverage area of farm. Then all other required inputs based on various dependency factors are automatically identified and taken by the e-calculator and provides the estimation results. This output result provides useful data on estimation of fertilizers cost/quantity, water, seeds, cultivation equipment cost, labour-day efforts/cost with labour-day effort distribution on calendar chart of crop life cycle, crop yield along with extrapolated market price at the harvest time and its profitability.

All the required inputs which are both linear and non-linear in nature are taken by farmer's data base, external information sources mentioned earlier. The inputs get processed by machine learning techniques and generate the estimation with feasibility study so that the farmer can choose the desired crop for cultivation.

7.3. Crop care service

The crop care service guidance spans right from the sowing of seeds as start point till the time of harvesting as endpoint. The complex structured data sampled from IoT sensors from the fields are analyzed along with the data collected from sources of information sites along with domain expert inputs wherever needed through Artificial Intelligence techniques. After the analysis of complete data, the overall corrective action item is derived out of PID (*Proportional Integral & Differential*) controller mechanism. Accordingly, the corrective measures are alerted to the farmer on their smart phone to prioritize the action based on severity and urgency to act upon.

7.4. Price prediction and market guidance

This service helps to safeguard the farmers from market fluctuation and mitigates the risk of price loss. Based on the statistical data collected from

various sources a predictive price and demand information is shared with the famers during the complete crop lifecycle. And hence the farmers can plan better for releasing their commodities to market.

7.5. Crop loan and insurance service

This service helps the farmers in facilitating feasibility of the getting, crop loan, processing support, eligibility criteria, loan limit as per the smart estimation made for the propose crop.

Also, it helps to get the crop insured as a mitigation plan for crop failures due to any uncertainties or calamities.

8. Conclusion

In this paper, we propose a high-level solution architecture for building a smart farming service model for Indian farmers. This smart farming service model ecosystem makes use of the existing information network sources, Digital IT solutioning to be built with Artificial Intelligence and Internet of Things. With a simple android app installed on any cost effective smart phone the registered farmers can avail the e-service of smart farming and serves as single point of contact as e-guru for all the queries and concerns of the farmers at nominal service rates. Also, it provides a business opportunity for entrepreneurs, IT companies to build and maintain this smart farming service system with reusable components. Also, the government policies and budgetary plans can provide subsidies and sponsor for this type of farmer betterment services. As a pilot run a prototype service model can be implemented and provide the service to the famers of certain identified sample zone through the sponsored stake holders.

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