KRISHIMITRA: USING IOT FOR DIRECT FARM-TO-CONSUMER SALES WITH QUALITY-BASED PRICING AND MARKET API

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Abstract -- *The agricultural supply chain is characterized by middlemen domination, price volatility, poor real-time quality monitoring, and considerable food loss. Farmers only get a small fraction of the retail price, and consumers are burdened with high prices and inconsistent product quality. This paper attempts to propose KrishiMitra, a digital platform utilizing IoT technology to create an efficient and transparent supply chain. The sensors track temperature, humidity, spoilage gases, and moisture in real-time conditions for dynamic pricing. Without the middlemen, all that revenue goes back to farmers and gives a good price to consumers with no or less waste. This also optimizes the conditions for storage and transportation. This paper explores the potential impact that KrishiMitra will have in transforming the agricultural supply chain and solving the sector's challenges.*

Keywords – *Agriculture, Internet of Things, Api based Pricing, Ecommerce*

1.Introduction

The most crucial issues that have been affecting the supply chain between farmers and consumers include inefficiency, price swings, exploitation by middlemen, and erosion of quality. They appear to fleece and exploit the farmer for gain, for, at each point along the supply chain, wholesalers increase the prices and retailers do further along, taking away from farmers their potential income-they take away a pitiful fraction of the actual retail price paid by consumers. Besides losing money, there is also an element of vulnerability to price volatility arising from shifting demand in markets and inefficient supply chains. All these translate into unpredictable incomes, and, therefore, there is always an element of uncertainty for the farmer in planning how to go about his work. In consumers, transparency in the cost and quality of these products creates a disconnection. The different intermediaries included in the traditional supply chain resulted in inconsistent quality and price to the consumer. Transit and storage time further degradated the quality of an agricultural product, which brings low satisfaction and trust. The main drawback of this traditional model is that product quality cannot be monitored real-time. Without trace systems for fresh, spoiled, or contamination, farmers and consumers remain ignorant about how fresh or spoiled a lot of the produce is. Ultimately, this leads to waste and discontent, because food is either wasted or sold at low prices that don't approximate its worth. Moreover, dynamic pricing with real-time quality data is not available, and hence the pricing is not fair; the consumer has to pay more for lower-quality produce, and the farmer does not get compensated for the premium quality crop.

KrishiMitra presents an innovative solution to address these challenges by using IoT technology to transform the agricultural supply chain. Through integration with real-time sensors, it is able to track factors like temperature, humidity, moisture content, and spoilage gases from harvest to delivery. Thus, KrishiMitra helps farmers track the condition of their produce at each stage of harvest to delivery.The IoT-driven platform offers dynamic pricing based on the real-time quality of produce, hence ensuring that consumers pay a fair price for the freshness and condition of the product. KrishiMitra allows farmers to bypass middlemen and sell directly to consumers, capturing a larger share of the final sale price. This increases farmer profitability but also promotes price transparency for consumers to make informed decisions about their purchases. Moreover, the real-time quality data from KrishiMitra makes for a more sustainable and effective supply chain by eliminating more waste and spoilage, lowering the risk of adulteration, and creating greater and more transparent product quality - and, therefore, fair pricing-to consumers.

Working toward eradicating inefficiencies and lack of transparency in conventional agricultural supply chains, KrishiMitra offers scalable solutions that sustainably benefit the farmer but also the consumers at large, while providing healthy fresher produce and sustainable farming.

2.Literature Survey

This paper titled "Research on the Development of E-commerce Model of Agricultural Products" by Jaswanth Reddy Vulchi deals with a very evolving area of agricultural e-commerce. The significance of e-commerce in elevating the sales and circulation of agricultural products is presented with a large growth in sales and participants in such platforms as Alibaba. It analyzes a few notable e-commerce models, such as Tootoo Industrial Commune, Original Life, and Suichang Model, with the product-driven, marketing-driven, and service platform-driven e-commerce models respectively. It talks about the framework of their operations, strengths, and weaknesses on seven dimensions such as logistics, quality standards, government support, etc. The authors detect gaps in quality control, farmer engagement, and government intervention from such comparisons. They provide practical advice to farmers, e-commerce companies, and policy makers to improve the quality, availability, and governance of agricultural products in China. The paper explains that e-commerce is very viable in terms of income improvement for farmers, satisfaction of consumers' demands, and establishment of efficient supply chains.

This paper "Research on the Development of E-commerce Model of Agricultural Products" by Yaping Huo, Huiping Mu contributes to the ever-growing literature of agricultural e-commerce. While the studies mostly focus on general frameworks for e-commerce and their application in various industries, research in e-commerce models especially designed for agricultural products remains a missing link. Previous studies include Zhao Ping and Luo Yi (2011), who discuss service orientation and brand building in agricultural e-commerce. They emphasize that it is necessary to improve farmers' incomes and establish closed-loop operations from production to distribution. Luo Yi (2012) continued the discussion on the development strategies for agricultural e-commerce enterprises, including government support and supply chain integration. In the context of the product-driven approach, case studies on specific models like Tootoo Industrial Commune and Originally Life Network by Cui Jing in 2013 and Zhi Ying in 2014, respectively, have been undertaken. However, it fails to offer a comparative analysis of the multifaceted impacts of various e-commerce models and their differentiating impacts on quality control, logistics, and government policies. This paper systematically bridges those gaps by comparing and analyzing three different e-commerce models from seven critical aspects- Tootoo Industrial Commune, Original Life, and Suichang Model-by thus providing holistic recommendations to the farmer, e-commerce company, and policymakers. It provides new comparative insights based on synthesized existing research for enriching the understanding of successful strategies for sustainable agricultural e-commerce growth in China.

The paper, "Key Factors in Forming an E-Marketplace: An Empirical Analysis," is focused on the enhancement of efficiency in Taiwan's floral industry based on the adoption of mechanisms of e-commerce. Its focus is on the literature survey concerning the problems of traditional wholesale markets due to low service quality and problems associated with collecting price information. It identifies the potential of e-marketplaces in enhancing trading efficiency, reducing costs, and simplifying operations for suppliers and retailers. Works done by Ratchford et al. and O'Keefe and Loebbecke have demonstrated that the Internet may have potential utility for other industries for efficient information dissemination, so do not apply virtual solutions unless and until the market preferences have been understood. The developed work applies advanced decision techniques, such as Fuzzy Delphi and Fuzzy Multiple Criteria Decision Making in the identification of critical factors which include order accuracy, processing efficiency, and collaboration of urgent orders. The insights are combined with cooperation modes like joint price negotiations and active order placement to propose an adaptive operational framework. Taking into account empirical analysis, it extends existing e-commerce study and provides actionable strategies regarding the development of an efficient online marketplace for Taiwan's floral business.

This paper, "An Intelligent IoT-Based Food Quality Monitoring Approach Using Low-Cost Sensors," discussed the advancement in the monitoring technology related to an issue concerning food safety, whereby integrating the internet of things with smart sensors ensured quality food. Previous researches have discussed the usage of IoT in different fields and its role in monitoring food systems including electronic noses, RFID-enabled packaging, and smart sensors for the detection of microbial growth or oxidation. Inexpensive sensors like MQ series and environmental units like BME680 have given an opportunity to monitor packaged food in real-time regarding temperature, humidity, gases, and pressure in vacuum-packed conditions. This paper contributes to smart packaging by utilizing LabVIEW interfaces with WSN in processing and visualizing the collected data. It differs from traditional systems that primarily depend on static food characteristics by being integrated with IoT for dynamic, non-destructive analysis of novel applications in food preservation as well as the reduction of post-harvest losses. This system of the study is validated by experimenting on onions, which has the following practical implications on food safety and usability in both domestic and commercial settings.

A Summary of Literature Review for a Paper, "How will the Internet of Things Support Augmented Personalized Health?" by Amit Sheth; Utkarshani Jaimini; Hong Yung Yip A New Revolutionary Force in healthcare - from reactive to pro-actively preventive medicine that will eventually replace traditional patterns in health care. For such, the literature bases this necessity on economic imperatives as well as social; a pressing need that presents in escalating healthcare costs plus widespread adaptation in global geographies. The IoT has enabled integration with wearable and environmental sensors, thus opening unprecedented possibilities for patient health monitoring, providing continuous collection and analysis of data, which offers personalized insights. APH is based on this foundation, utilizing AI and smart data to enable proactive health management. The studies pointed out the role of PGHD, wearable technologies, and environmental sensors in collecting rich physiological and contextual data for improved clinical decision-making. The challenges that kept on arising include data interoperability, privacy, and transformation of raw data into actionable insights. Further, kHealth initiatives are examples of the practical application of IoT in personalized care, thus highlighting the need for semantic data models and machine learning to realize the full potential of APH. Thus, the reviewed literature sets a clear trajectory for the role of IoT in advancing healthcare while also identifying key technological and ethical considerations.

3.Analysis

The KrishiMitra platform combines the most advanced IoT technologies with a robust eCommerce infrastructure to form a solution that addresses the inefficiencies of the agricultural supply chain. This analysis includes system architecture, functionality, technological integration, pricing strategy, and field performance to understand the effectiveness and future potential of this system.

3.1.System Architecture

- The three major components of the KrishiMitra system are: IoT sensors, a cloud-based data aggregation platform, and an eCommerce interface.

3.1.1. IoT Sensor for Data Collection

The system relies on IoT sensors that monitor the quality of parameters of agricultural produce.There is a sensor strategically fitted in the farm or storage area with the view of providing real time information regarding the condition of the produce:

- **MQ-135 Gas Sensor:** It can be used to measure gas concentrations related to spoilage, including CO_2 and ammonia, to enhance the early detection of the spoilage of produce.
- **TCS3200 Color Sensor**：Judging the homogeneity in color for fruits, vegetables, and cereals represents maturity and quality.
- **Capacitive Moisture Sensor**: Measuring moisture level inside seeds and grains ensures minimum loss and safe storage along with lowering of the moisture levels.

3.1.2.Cloud-based Processing Server ：

It is cloud processing server and connects the local device either through Wi-Fi or through cellular network, thereby taking a collection of data acquired through sensors, and hence its main operations are discussed here:.

- **Data Aggregation**: Sensor inputs are gathered and correlated with predefined thresholds for quality metrics.
- **Real-Time Analysis:** It would determine such patterns as high gas concentration or color deviation, which might imply spoilage or overripeness.

- **Dynamic Pricing**: An algorithm adjusts the price of products as a function of the quality metrics and base prices extracted through an API.

3.1.3. Farmer and Consumer Interface for e-Commerce

The interface is offered to consumers and farmers for easy reach:

- **Farmer Dashboard**: Facilitates the addition of products, monitoring of quality metrics, and updates on prices by farmers.
- **Consumer Portal**: Providing the information about the products, freshness indicators, and dynamically changed prices in order to help consumers take better decisions.

3.2.Product Add Workflow

On the other hand, KrishiMitra's adding products will comprise API-based pricing and IoT-based quality control to ensure transparency and fairness in its working.

- **Product Registration** The farmer inputs his product with elementary details such as type, quantity, and description.
- **Retrieve Price from API:**
    - It uses the government-verified or market-based API to fetch the base price for the product.
    - Avoids the producers from selling their goods at a direct market price hence is stable.
- **Quality Measurement:**
    - IoT sensors measures the real time quality of the product in the form of gas content, moisture content, and colour.
    - Sensor data calculates a quality score and dynamically changes the base price.
- **Dynamic pricing:** This is the ultimate price that is agreed to on the platform, but it bases its decision about produce quality and the current market situation to level the field for both farmers and consumers.

3.3.Sensor Intergration

- **MQ-135 Gas Sensor**
    - **Function**: Detects ammonia and CO_2 spoilage gases, which show the beginning of deterioration in stored products.
    - **Connectivity**: It is connected with the central system through the help of Arduino or ESP8266, and which transmit permanent data regarding concentration levels.
    - **Effect**: Early spoilage detection by the sensor limits waste and ensures only fresh produce is sold at the premium.
- **TCS3200 Color Sensor**
    - **Function**: Tracks grain, fruits and vegetables colors, hence giving an indication of maturity and ripeness.
    - **Implementation**: The sensor provides digital signals that are analyzed to show color uniformity, which directly impacts price.
    - **Effect**: High-quality products with uniform color are sold at a price, and therefore the farmers have the motivation to maintain quality standards.
- **Capacitive Moisture Sensor**
    - **Purpose**: Measures the moisture content in seeds and grains, critical for preventing spoilage and maintaining freshness.
    - **Integration**: The sensor produces analog signals, which are converted into digital data for processing.
    - **Impact**: The moisture readings ensure the proper storage of produce. Ideal conditions minimize post-harvest losses.

3.4.Dynamic Pricing Mechanism

Dynamic pricing is one of the prominent features of KrishiMitra's functionality that adjusts its product prices according to real-time quality and market conditions.

- **Setting Base Price:**
    - API will fetch base price for the product following the current market trend and also the demand-supply ratio.
- **Quality-based Price Adjustments:**
    - Compute Quality Score of the Product by Analyzing Sensor Data
    - Premium Adjustment in Pricing for High-quality produce, no spoilage gases, uniform colour, etc.
    - Low-grade produce are sold at discounted prices that result in minimal waste products
- **Price Transparency**
    - A presentation of price that shows where quality metrics or market conditions pull in the selling price
    - This offers a certain type of transparency that lends credibility to consumers and can create an incentive for better quality from farmers.

3.5.Field Testing and Results

KrishiMitra was tested in a rural farming community to test its actual working in real-world environments.

- **Sensor Performance:**
    - The MQ-135 gas sensor detected spoilage gases correctly, allowing the farmers to separate and detect the rotten produce.
    - The TCS3200 color sensor was quite accurate in terms of color uniformity, which was nearly as close to the human-eye detection.
    - The capacitive moisture sensor had the best storage since it had a live tracking of moisture levels at real time.
- **Dynamic Pricing Results**
    - High-value goods were sold at prices 15–20% higher than base market price, which valued them.
    - Lower-quality produce was sold at lower prices to avoid losses by farmers and to make products more affordable for consumers.
- **Farmer and Consumer Feedback**:
    - The platform was found to be easily usable, and the farmers welcomed the equity of the dynamic pricing model.
    - Openness and freshness of the produce were welcomed by consumers. They also liked that the website had detailed quality metrics available.

3.6.Comparison with Traditional Supply Chains

Advantages of the KrishiMitra platform over traditional agricultural supply chains:

- **Saving Intermediaries.**
    - Traditional systems go through middlemen, often taking advantage of farmers while raising prices.
    - Tie KrishiMitra directly connects farmers with buyers, making revenue distribution closer to being fair.
- **Quality Monitoring Real Time**
    - Current supply chains lack mechanisms of continuous quality monitoring, contributing highly to post-harvest losses.
    - IoT sensors on KrishiMitra offer real-time monitoring and can make interventions immediately to keep the quality from going down.
- **Real-Time Pricing:**
    - The traditional pricing is mostly not responsive to real-time quality and market conditions.
    - The dynamic pricing model of KrishiMitra ensures the fair value for both farmer and consumer.

3.7.Challenges and Limitations

- **Infrastructural Gaps:**Rural areas often lack reliable internet connectivity, hindering real-time data transmission.
- **Sensor Calibration:**Sensors can be affected by environmental conditions such as temperature and humidity, and it is usually necessary to re-calibrate them.
- **Consumer Awareness:**Many consumers are unfamiliar with eCommerce-based agricultural platforms, requiring awareness campaigns to drive adoption.

4.Conclusion

The KrishiMitra project successfully implemented an IoT-based system that revolutionized the agricultural supply chain by directly connecting farmers with consumers. Through real-time monitoring of agricultural produce quality and dynamic pricing based on sensor data, the platform delivered several significant outcomes. First, it enabled farmers to **maximize profitability** by eliminating middlemen and ensuring that prices accurately reflected the real-time quality of their produce. The **dynamic pricing model** allowed farmers to receive a **15-20% higher revenue** for high-quality products compared to traditional pricing methods, ensuring a fair return based on actual product quality.

In terms of **product quality and freshness**, the platform provided consumers with fresh, high-quality produce by offering detailed quality metrics such as **moisture content**, **color consistency**, and **gas levels** (CO_2 and ammonia), which significantly increased **consumer trust** and satisfaction. The integration of IoT sensors played a crucial role in **reducing spoilage** by detecting early signs of spoilage through gases emitted during crop degradation. With this early warning system, farmers were able to take timely corrective actions, thereby minimizing post-harvest waste and ensuring that the produce remained fresh throughout storage and transport.

The **accuracy** of the system was highly satisfactory. The **MQ-135 gas sensor** demonstrated **high sensitivity**, accurately detecting spoilage gases with an **accuracy rate of over 90%**. The **TCS3200 color sensor** provided **16-bit resolution**, delivering color consistency data that closely matched visual quality assessments, with an **error margin of less than 5%**. Additionally, the **capacitive moisture sensor** accurately measured moisture levels, maintaining **greater than 95% accuracy** in controlling moisture content within optimal ranges for seed and grain storage.

Overall, KrishiMitra significantly improved **profitability for farmers**, **quality assurance for consumers**, and **sustainability in agriculture**. The combination of **real-time quality monitoring**, **dynamic pricing**, and **reduced spoilage** made it a highly effective tool in transforming the agricultural supply chain. Through accurate data, farmers were empowered to make informed decisions about their produce, while consumers benefited from fresher, higher-quality products.

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