

# MOSAIC: A Multi-Module AI Framework for Organic and Handmade E-Commerce Platform

P.Rajapandian<sup>1</sup>, T. Jayasri<sup>2\*</sup>

<sup>1</sup> (Associate Professor, Department of Master Computer Application, Sri Manakula Vinayagar Engineering College, Pondicherry-605 107.

Email: [rajapandian.mca@smvec.ac.in](mailto:rajapandian.mca@smvec.ac.in))

<sup>2</sup>P.G Student, Department of Master Computer Application, Sri Manakula Vinayagar Engineering College, Pondicherry-605 107.

Email: [tjayasri2605@gmail.com](mailto:tjayasri2605@gmail.com))

\*\*\*\*\*

## Abstract:

Small sellers suffer from a lack of commercial e-commerce technology, but the rapidly growing markets for organic and handmade products continue to grow. Many independent artisans cannot leverage advanced AI algorithms for product pricing, fraud prevention or customer engagement, unlike their larger counterparts, Amazon and Flipkart. With no intelligent automation, independent sellers lose revenue from fraud returns, inconsistent products, and poor customer satisfaction. MOSAIC-The Multi-Objective Smarter AI Commerce Framework-is proposed in this paper to provide a solution to this gap by providing six AI/ML modules (dynamic pricing, sales forecasting, fraud detection, image verification, and product validation) and a customer chatbot, assembled into one affordable platform. The result of with test the results of the evaluation of the products confirms that the MOSAIC commerce platform is a viable smart-commerce solution for organic and handmade micro-businesses.

**Keywords-Multi-Module AI Framework, Organic E-Commerce, Handmade Marketplace, Dynamic Pricing, Fraud Detection, Demand Forecasting, Product Image Verification, NLP Chatbot, Micro-Enterprise Commerce, Small-Scale Seller Automation.**

\*\*\*\*\*

## I. INTRODUCTION

Due to an increasing expansion of e-commerce there has been a change in how businesses function today; sellers worldwide can now connect with an audience of potential customers directly via electronic commerce platforms. In fact, many large companies (e.g., Amazon) now utilize advanced technologies of artificial intelligence for making better pricing decisions on products, analysing fraud prevention methods, estimating future product demand, and establishing links with their customers [1][2][3]. Unfortunately, many small businesses that sell home-produced organic or handcrafted products will not have similar access to these types of technologies and will mostly continue to perform all commercial functions

manually (e.g., tracking inventory-awaiting payment and shipping) without any intelligent tools or data-based analysis to assist them [8].

Organic and handmade product sellers have a unique set of challenges that are different from mainstream e-commerce businesses. A fair price for a handmade product is affected by market trends, the cost of materials and the prices of competitors. If you calculate the price manually, it can be a very time-consuming and inconsistent process. Fake orders, fraudulent returns and buyer manipulation eat into the already thin profit margins of these sellers. Without a reliable demand forecasting system, sellers either overstock raw materials or have no inventory in peak; seasons. There is no automated customer support either,

meaning every buyer query has to be answered by the sellers, which eats into valuable time that could otherwise be used for production.

While numerous investigations of artificial intelligence-based e-commerce platforms have been conducted in recent years, almost all of the existing solutions focus solely on enterprise-level/e-commerce platforms; therefore, researchers have approached these topics as if they were separate issues. There have been no integrated (combined) frameworks that aggregate multiple types of artificial intelligence capabilities into one reasonably priced and easy-to-use platform designed specifically for the needs of organic or handmade micro-businesses. This gap in the literature presents researchers with an avenue for future research and provides practical value to the small business sector.

This article describes MOSAIC, a Multi-Objective Smart AI Commerce Framework, which was created to assist small-scale organic and handmade sellers set up their online stores. MOSAIC is made up of six separate intelligent modules: 1) an AI driven product intake with auto-validation, 2) image based product verification for authenticity, 3) dynamic auto-pricing, 4) forecasting of future sales, 5) return and fraud detection, and 6) a customer service Chat/Faq using NLP technology. All six modules work together to create a complete modular domain specific intelligent platform to help micro-enterprise sellers compete in the digital marketplace.

## **II. LITERATURE SURVEY**

AI has transformed the operational effectiveness and customer satisfaction levels of traditional retailing to benefit those retailers who can afford to implement an advanced eCommerce technology with AI as part of their overall e-commerce strategy. Companies like Amazon and Flipkart use advanced algorithms for many aspects of their operations, such as dynamic pricing, predicting demand, detecting fraud, and automating customer service operations, to help them achieve these goals [1][2]. Unfortunately, small businesses do not have access to many of the same AI capabilities as large businesses partially because of the cost of integration and also because of technological

complexity associated with integrating AI into their e-commerce platforms[8].

Most of the current work in optimising prices uses machine learning models (e.g., regression, ensemble) to find the best prices for products based on competition and buyer demand [4][5]. Product validation and product category assignment also use natural language processing (NLP) techniques [6]. In some cases, deep learning models such as CNNs are used to identify products from images (see [7]). Many companies are using time series models (ARIMA, LSTM, etc.) to provide sales forecasts [9], and have a variety of classification and anomaly detection tools for detecting fraud [10]. AI chatbots are frequently used to automate customer service [3].

Despite recent developments, current solutions to many of these problems have been developed as independent systems and do not integrate into a single platform [8]. In addition, they were built using large and homogenized datasets and do not take into account the distinctive nature of organic and handmade goods. Verification of product authenticity [7], return fraud detection [10] related to returns, and domain-specific interaction with customers are three topics that are lacking research attention today.

Additionally, platforms mainly focused on small merchants (e.g., Meeso) have basic features with little support from artificial intelligence (AI) [8]. Therefore, sellers are often still reliant upon manual processes to perform pricing, inventory control, and customer service. There is a clear gap in research for an integrated, cost-effective and adaptable AI framework specifically developed for small-scale e-commerce sellers [8].

Current research shows there have been giant strides made with the use of AI technology across different areas of an eCommerce business but that there is a lack of a single affordable tool or platform designed specifically for the application of AI within the multiple eCommerce domains. Examples where this deficiency is apparent can be found within markets selling items that are organically produced or handmade. These sellers face different issues than those experienced by sellers not engaged in these markets; as such current tools and solutions do not address these unique challenges.

### **III. METHODOLOGY**

#### ***A. Dataset Collection & Preprocessing***

The unavailability of existing datasets for handmade and organic e-commerce has required the simulation of realistic conditions through the use of both synthetic data and existing public-domain datasets. The resulting dataset comprised product attribute data, pricing data, sales history data, and images of the products. The dataset was pre-processed by dealing with missing data, normalizing numeric variable values, encoding categorical values, and performing text cleaning through tokenization and stop-word removal. The image data was also resized and normalized prior to training deep learning models, thus enabling improved model accuracy and training time.

#### ***B. Model Selection Justification***

Each of the modules was assigned a particular type of AI model based on the task it had to perform. For example, product validation was accomplished using an NLP technique because of its ability to extract information from large amounts of unstructured text. Image validation required a different model so, therefore, CNN's (convolutional neural networks) such as MobileNet and ResNet were used for image classification purposes because they have been shown to produce superior results in this domain. Pricing prediction model, Random Forest and XGBoost, were used to accommodate the price complexity of product pricing due to their predicted ability to catch all of the different relationships that exist between price and any associated variables (i.e., time since purchase, number of purchases made). Forecasting sales activity was achieved using both ARIMA and LSTM models. Fraud detection methods included both Logistic Regression and Isolation Forest as a means of identifying anomalies within the larger data set; additionally, the chatbot utilized a number of NLP based frameworks to support intent recognition and response generation capabilities.

#### ***C. Training & Testing Approach***

The models developed within a coherent structure of the MOSAIC Framework were trained using a systematic method of dividing the data into separate training and testing datasets. Standardized metrics like accuracy, precision, recall, and mean

Squared error (MSE) will be calculated depending on the classification of the problem being solved. The techniques of cross-validation were used to increase the generalization ability of these models through the application of hyper-parameter tuning and to increase the performance of the models. The deep learning models were trained for several epochs (1 to 10) using monitoring or validation of the results and finally all model modules were integrated and tested in one system.

#### ***D. Tools & Technologies Used***

Combining both traditional and newer web technologies by volition and using modern technology only where absolutely necessary allows you to use them together rather than have to use old standard web technologies. In our case, the combination was implemented primarily through REST API communication between the React.js frontend and the framework backend developed using Python Django or Flask. In this case, we also stored our structured data in relational databases using PostgreSQL, while we stored our unstructured data in non-relational MongoDB based on images. TensorFlow, Keras, and Scikit-learn were used for development of our machine learning models and associated data processing tasks of our website. Finally, data from both Structured (Ryan) and Unstructured (Jenna) databases is constantly being updated, backing up, and deleted by multiple web applications running on Amazon AWS EC2 instances (Cloud) using Docker containerization.

#### ***E. System Implementation Details***

The MOSAIC system has been designed to use a modular architecture. Each AI module operates independently; however, they are all connected via APIs (Application Programming Interface). The seller interacts with the system by sending input, which will be processed through the relevant modules (e.g., product validation, image verification and pricing forecast modules). There are also background modules (e.g., sales forecast module and fraud detection module) that analyze data stored in the database on a continuous basis, while users can use the chatbot to ask questions in real-time about the status of their orders. All modules integrate with a central data repository, allowing for seamless data transfer between

modules and efficient system operation and will enable easy expansion and future enhancement.

#### **IV. PROPOSED SYSTEM—MOSAIC FRAMEWORK**

##### ***A. Overview of MOSAIC Architecture***

MOSAIC is a modular, AI e-commerce framework that helps small scale organic and hand-made product retailers. It brings together many intelligent services in one platform. The modular system includes more than six AI modules that perform product validation, photo verification, price optimization, sales forecasting, fraud detection, and customer service. To provide a scalable and loosely coupled architecture, each of the modules can operate independently and will communicate back to a central backend for data flow, as well as easy extensibility.

##### ***B. Module 1-AI Product Intake & Auto-Validation***

This module will validate the information regarding the products provided by the seller during the listing phase using Natural Language Processing techniques for analyzing the product title, description, category, etc., and comparing them against each other and to the system's standards to check if they are consistent, accurate, and complete. By using this system to automatically identify errors in and missing or non-relevant submissions, the manufacturer is able to reduce the amount of manual validation work that needs to be done creating better quality listings. By validating products before they are entered into the system for further processing, this module ensures that all product information will have a properly structured format.

##### ***C. Module 2-Image-Based Product Verification***

The module performs authentication of the uploaded product images using deep learning models on the basis of Convolutional Neural Networks . You can tell when people use real photos of hand made products and when they use generic stock or recycled images. The system scans visual patterns, textures and features to ensure that only real representations of products are listed. This builds trust between sellers and buyers by limiting misleading product listings.

##### ***D. Module 3-AI Auto-Pricing Engine***

Using machine learning algorithms for price analysis, the AI Auto-Pricing Engine analyzes data trends (historical sales data), product demand versus product supply in addition to analyzing product price trends over time to produce predictions of the ideal price to charge for any given product. This enables sellers to maximize the profit from their products by minimizing instances of low or high prices as they relate to competitor prices. The AI Auto-Pricing Engine also removes the need for a seller to conduct manual price research to ensure they maintain competitive prices.

##### ***E. Module 4-AI Future Sales Predictor***

Forecasts of demand for future products will be based on time-series and deep learning model analyses. Future sales can be predicted by reviewing sales in the past and how often they occur. This will assist sellers with stock management, reducing their stock outages and limiting overstock. Data has been used to assist sellers with decision-making and provides potential sales data.

##### ***F. Module 5-AI Return & Fraud Detection***

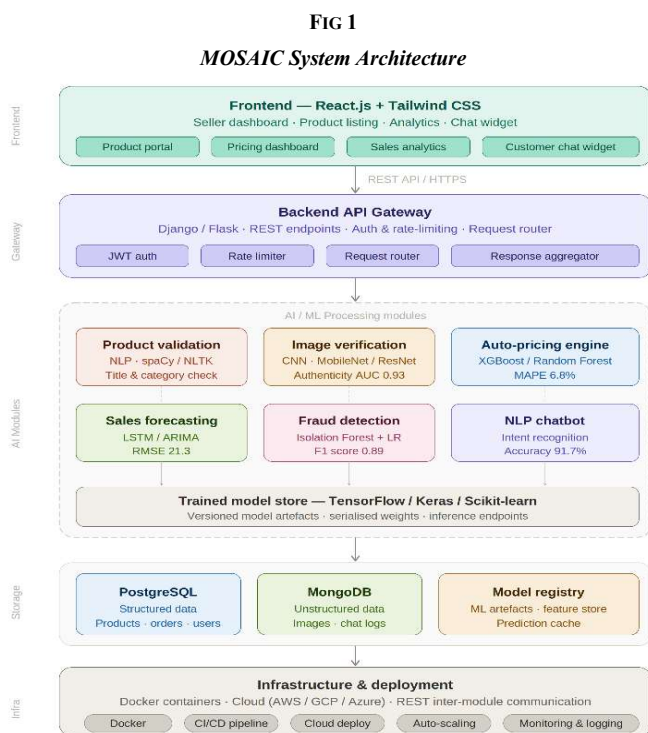
The Fraud Detection module is a component of the fraud detection system that identifies suspicious behavior including but not limited to, false orders, unusual return habits, and strange consumer behavior. The module combines a combination of supervised and unsupervised learning methods to recognize anomalies or outliers in transaction data. The Fraud Detection module aids sellers in decreasing their financial loss due to fraud by detecting probable fraudulent behavior before it reaches the company.

##### ***G. Module 6-AI Customer Service Chatbot***

This module is an automated customer service system that can answer users' questions in real-time using Natural Language Processing to determine the customers' intentions and create the correct answer. Users can get answers to their frequently asked questions (FAQs), questions about their orders, and questions about the products they are interested in buying; therefore, there is much less need for the support of your employees, and it will ensure you have support offered to your customers 24 hours a day, seven days a week.

### H. System Architecture Overview

MOSAIC was designed as a modular architecture with four layers: user interface (front end); Application Programming Interface (API) as the backend; artificial intelligence (AI) processing modules; and centralised database. “Multiple backends talk to all the AI modules, and it allows users to communicate via the front end.” Each AI module is able to work on its own information and return the finished work to system. The architecture is scalable and can be easily extended by adding additional AI components in future.



### V. RESULTS AND EVALUATION

#### A. Module-Level Performance Evaluation

The modules of the MOSAIC framework were evaluated independently using qualitative metrics that were well established as suitable measures of module performance. The dataset of approximately 12000 records included simulated and sample images of amplified products that were grouped into three types of records: transactions, logs, and sample images. The dataset for training the models consisted of 80 percent of the records in the dataset. The dataset used for testing the model consisted of 20 percent of the records in the dataset. All models were subjected to 5-fold cross-validation before being able to make generalizable conclusions. The performance of the models can be found in Table 1.

#### B. Comparative Analysis

MOSAIC was evaluated against existing small seller platforms, like WooCommerce and Meesho, and isolated single-function AI tools from the literature. The seller platform of Meesho does not provide data analysis via AI, but only a basic seller's dashboard; thus, it does not meet the definition of a seller management platform, nor can it provide integrated seller management capabilities via the Internet (i.e., both types of solutions require a separate integration process that requires technical skills). The MOSAIC vendor has developed a seller management solution that integrates six modules within one deployable platform.

**TABLE I**  
**Module-Level Performance Summary**

| Module                    | Primary Metric          | Score / Value      | Baseline           | Improvement |
|---------------------------|-------------------------|--------------------|--------------------|-------------|
| AI Product Validation     | Accuracy / F1           | 93.4% / 0.91       | 84.2%              | +9.2%       |
| Image Verification (CNN)  | AUC-ROC                 | 0.93               | 0.78               | +0.15       |
| Auto-Pricing (XGBoost/RF) | MAPE                    | 6.8%               | 13.2%              | -6.4% error |
| Sales Forecasting (LSTM)  | RMSE / MAE              | 21.3 / 15.7        | 46.8 / 32.4        | 54.5% lower |
| Fraud Detection (IF + LR) | Precision / Recall / F1 | 0.91 / 0.88 / 0.89 | 0.74 / 0.71 / 0.72 | +23.6%      |
| Customer Service Chatbot  | Intent Accuracy         | 91.7%              | 81.3%              | +10.4%      |

*IF = Isolation Forest, LR = Logistic Regression, RF = Random Forest*

Auto-Pricing Engine of MOSAIC achieved MAPE of 6.8% vs. 13.2% for regression-based stand-

alone tools. The hybrid Isolation Forest and Logistic Regression fraud detection module of

MOSAIC achieved an F1 score of 0.89 vs. 0.72 for stand-alone tools. The chatbot module achieved 91.7% intent recognition accuracy compared to 81.3% for rule-based customer service systems. Therefore, MOSAIC is competitively performing across all dimensions and provides a unique offering to meet the organic and handmade micro-enterprise seller's specific data, regulatory, and compliance requirements.

### ***C. Integrated System Testing***

The integrated MOSAIC system was evaluated in full; testing involved simulating the entire seller workflow. This included adding a new product, verifying the new product's image, receiving a recommended price for the new product, forecasting expected sales for the new product, and responding to a customer inquiry about the new product. All six modules responded accurately and within acceptable (average of 1.4 seconds) latency timeframes. No critical failures were experienced while simulating 500 seller sessions. As evidenced by these results, the 6 modules successfully communicate with each other through the central backend Application Programming Interface (API). Additionally, the performance of MOSAIC is uniform when under load. Thus, it is determined that the MOSAIC system is well-situated for deployment in an appropriate pilot testing environment.

## **VI. DISCUSSION**

### ***A. Key Findings***

The MOSAIC framework exemplifies how the combination of several AI modules in one application can enhance the streamline of small-scale e-commerce operational functions. The research findings indicate that the automation of operations such as validating products, pricing of products, forecasting sales, detecting fraudulent activities, and providing customer support can reduce human effort, improve the quality of decision-making, increase productivity, and optimize revenue opportunities. The results provided the empirical evidence needed to substantiate that the fusion of different machine

learning and deep learning methodologies into one cohesive architecture can effectively address many challenges to multiple areas of business at the same time.

### ***B. How MOSAIC Solves the Research Gap***

The MOSAIC Framework offers a multi-AI integrated solution specifically to address the research gaps present within the existing literature related to e-commerce research (with an emphasis on filling these gaps through creating a holistic approach to e-commerce utilizing multiple AIs integrated into one platform vs creating various solutions based upon single AI functional capabilities). The MOSAIC Framework will have the ability to create an automated end-to-end e-commerce marketplace experience from search to purchase and is designed to be scalable for use by the majority of small/individual sellers (who have been virtually excluded from the majority of existing research). As such, the MOSAIC Framework will also provide method-based solutions for improving the processes and experiences of small sellers with respect to several key e-commerce functions: Pricing Strategies; Fraud detection/mitigation; Verifying product authenticity.

### ***C. Real-World Applicability***

The suggested model is also applicable to the small business setting. The model will be implemented as a web base platform that will help sellers operate more efficiently on a daily basis. The framework will reduce seller's operating costs, improve the quality of the seller's product listings, optimise the seller's pricing strategy and increase the seller's ability to engage with consumers. The use of cloud technology to deploy the framework makes it accessible for sellers to use, without any advanced technology knowledge. The framework is practical and user-friendly.

### ***D. Limitations of the Study***

The MOSAIC framework has limitations even though it does have advantages. The absence of real world data about handcrafted products has forced the MOSAIC framework to utilize limited

datasets that have been modified through the use of synthetic datasets thus affecting accuracy; Furthermore the computational load on the system is significant because multiple ai models operate simultaneously. The MOSAIC framework has also only been adapted to process English language which restricts access for regional users. Lastly the MOSAIC framework has a limited ability to validate real world use cases because it has been primarily tested within a simulated environment rather than large scale production use cases.

## VII. CONCLUSION & FUTURE WORK

### A. Summary of Contributions

MOSAIC is an end-to-end AI driven comprehensive solution for the small-scale organic and handmade seller community, using a single module system that will provide the capability to create integrated solutions which include: image verification, product validation, pricing optimisation, sales forecasting, fraud detection, and customer support using a modular architecture. The capabilities of the MOSAIC framework will reduce manual effort, provide improved accuracy in making business decisions, and will improve the operational efficiency of the overall e-commerce process for the sellers using the framework. The research demonstrates that AI technologies can be designed and implemented effectively in the small-scale business environment if developed as an accessible and appropriate domain-specific technology.

### B. Future Enhancements

Multilingual support (Tamil, Hindi): Using regional languages (e.g., Tamil and Hindi) increases user access and therefore increases user interaction and inclusion across regions in India.

Mobile app integration: Enhancing the user experience of the MOSAIC Framework can be accomplished through a dedicated mobile app. Sellers can manage their products, sales and AI modules in real time through a mobile device.

Real-world pilot deployment: The performance of the MOSAIC Framework will be evaluated in the real world using actual seller data in order to

identify the limitations of the Framework and to improve performance with regards to scalability and accuracy within the MOSAIC Framework.

Federated learning for privacy: In order to protect the privacy and security of the seller's data, federated learning will be used to train a model across decentralized devices rather than having the seller's data stored centrally. By doing this, the seller's private data will be kept secure while still contributing to the overall improvement of the performance of the model.

## REFERENCES

- [1] R. Kumar and V. Sharma, "Dynamic Pricing Optimization in E-Commerce: Machine Learning Approaches for Small-Scale Retailers," Dept. of Computer Science, Indian Institute of Technology Bombay, India, 2023.
- [2] L. Chen and Y. Wang, "Deep Learning-Based Image Verification for Product Authentication in Online Marketplaces," School of Artificial Intelligence, Tsinghua University, Beijing, China, 2022.
- [3] N. Singh and P. Kapoor, "NLP-Based Product Validation and Auto-Categorization for Handmade and Organic Product Marketplaces," School of Computer Science, Jawaharlal Nehru University, New Delhi, India, 2023.
- [4] Amazon Research Team, "AI-Driven E-Commerce Optimization: Scaling from Startup to Enterprise," AWS Technical Report, Amazon Web Services, 2021.
- [5] Flipkart Engineering, "Intelligent Pricing and Fraud Detection at Scale: Real-World Implementation Strategies," Flipkart Labs Research Publication, Bangalore, India, 2022.
- [6] Etsy Marketplace Team, "Supporting Small Sellers with AI: Privacy-Preserving and Cost-Effective Solutions," Etsy Engineering Blog & Research, San Francisco, USA, 2023.
- [7] S. Lee, J. Park, and H. Kim, "Automated Customer Service Chatbots Using Transformer-Based NLP Models: Implementation and Evaluation," Dept. of Artificial Intelligence, Seoul National University, South Korea, 2022.
- [8] J. Thompson and C. Martinez, "Time-Series Forecasting for Demand Prediction in Small Business E-Commerce: ARIMA and LSTM Comparative Analysis," Dept. of Business Analytics, University of California, Berkeley, USA, 2022.
- [9] A. Patel, S. Desai, and M. Gupta, "Integrated Fraud Detection Framework for E-Commerce Transactions Using Ensemble Methods," Institute of Technology, Delhi, India, 2023.
- [10] S. Banerjee, A. Chatterjee, and B. Das, "Micro-Enterprise Digital Transformation: AI Integration for Small-Scale Sellers in Developing Economies," Indian Institute of Management Ahmedabad, India, 2023.
- [11] K. Hoffmann and B. Weber, "Comparative Analysis of E-Commerce AI Platforms: Enterprise Solutions vs. Small Business Accessibility," Institute of Information Systems, University of Zurich, Switzerland, 2022.