Accelerating Cross-pollination of knowledge among farmer communities: Multi-Agent AI to enable Multimodal Content Transformation

Anonymous Submission

Anonymous affiliation

Abstract

Sharing best practices in agriculture from one region to another can lead to awareness and cross-pollination of ideas between farmer groups. Farmer to farmer videos are an excellent source of sharing best practices, but can a farmer in Africa learn from an Australian farmer? Barriers to such cross-pollination best practices across countries/regions is because of language/ cultural/ literacy / economic barriers.

This paper develops a novel Multi-Agent Artificial Intelligence system designed to overcome these challenges by dynamically transforming multimodal agricultural content. We develop Multi Agent based Multimodal AI that can boost learner's interest in the agri sciences, improve improve understanding, thinking and reasoning skills.

Multi Agent AI first comprehends the local language video, then generates new content in the new language, all dynamically planned by a set of intelligent AI agents. Such transformation of format of content be valuable aid in educating farmers across the barriers of language and geography.

The system's key capability lies in its strategic planning for multimodal content synthesis, effectively re-representing complex video content into an accessible text-and-image format. Our experimentation demonstrates the system's ability to ingest a farmer-to-farmer video on topics like regenerative agriculture and generate two key outputs: (1) a simplified, illustrated article representing the core concepts in a target language, and (2) a corresponding set of question-and-answer pairs to facilitate knowledge assessment and reasoning.

By enabling farmers to learn from peers across the globe despite linguistic and geographical obstacles, this AI-driven approach offers a scalable solution to democratize agricultural knowledge, foster a global community of practice, and accelerate the adoption of farming techniques worldwide. By learning to re-represent a video content into an easy to understand article with images, we enable cross-pollination of best practices in agriculture across farmer communities.

Code — https://sites.google.com/view/ai-multimodal-sharing-agri/home

Introduction & Motivation

The global agricultural landscape is facing unprecedented challenges, including climate change, food security for a growing population, and the need for sustainable practices. The dissemination of effective and sustainable agricultural practices is crucial to address these issues. Farmer-to-farmer knowledge exchange has proven to be a powerful mechanism for innovation and adaptation, fostering trust and a sense of community. However, significant barriers hinder the free flow of this invaluable knowledge across geographical and cultural boundaries. These obstacles include differences in language, literacy levels, and the context-specific nature of traditional farming knowledge.

Traditional agricultural extension services, while vital, often struggle with scalability, reach, and keeping information up-to-date. While digital platforms have emerged to facilitate knowledge sharing, they often do not overcome fundamental linguistic and cultural divides. For instance, a video demonstrating a water-saving irrigation technique in Australia could be highly beneficial to a farmer in a water-scarce region of Africa, but the language and context present a formidable barrier.

This is where Artificial Intelligence (AI) presents a transformative opportunity. The advent of powerful multimodal AI models and agent-based systems offers a novel solution to the long-standing problem of cross-cultural knowledge dissemination. These technologies can understand and process information from various modalities, including video, audio, and text, and can generate new, contextually relevant content in different languages.

Contribution

This paper proposes a Multi-Agent AI system designed to dynamically transform multimodal agricultural content, specifically farmer-to-farmer videos, to make it accessible and understandable to farmers globally. By leveraging the capabilities of Multimodal Large Language Model like Google Gemini and the Agent Development Kit, this system can analyze a video in its original language, comprehend the agricultural practices being demonstrated, and then generate a variety of educational materials—such as illustrated articles and interactive quizzes—in the target farmer's local language.

This approach not only transcends language barriers but also adapts the content to be more easily digestible and culturally relevant, thereby fostering a global community of shared agricultural wisdom.

Our work aims to demonstrate the feasibility and effectiveness of such a system in enabling the cross-pollination of farming knowledge, with a particular focus on sustainable agricultural sciences.

Literature

This research is situated at the intersection of several domains: agricultural knowledge exchange, and applied artificial intelligence, specifically in the areas of multimodal content processing, multi-agent systems, and educational technology.

The efficacy of farmer-to-farmer knowledge exchange is well-documented. This social learning process builds upon trust and shared experience, making it a powerful vehicle for practice change. [6, 19]. However, the scope of this exchange is often limited by geography and pre-existing social networks. [19]. Significant barriers, such as linguistic and cultural differences, illiteracy, and lack of access to technology, prevent valuable local and indigenous knowledge from scaling globally. [3, 22] Scholars note that without mechanisms to bridge these divides, farming communities can become closed networks, unreceptive to new and potentially beneficial external knowledge.

Recent advancements in generative AI are finding extensive application in education for assessment, evaluation, and creating learning environments. [4, 23]. A key area is Automatic Question Generation (AQG), where AI systems can create questions from source material to reinforce learning and assess comprehension [5, 25] . Research has shown that using AI to generate short-answer questions can enhance students' long-term memory and improve learning outcomes [25] . Applying AQG to the agricultural domain, especially in a farmer's local language, is a promising avenue for improving knowledge retention.

Furthermore, the challenge of understanding and repurposing video content is being addressed by the field of multimodal AI. Historically, video summarization was a computer vision task focused on selecting keyframes [2, 21] Now, with the rise of powerful vision-language models, multimodal systems can generate textual summaries from video, audio, and text inputs, creating a bridge between visual content and linguistic understanding [2, 14 ,18]. This convergence allows for a much deeper comprehension of video content, making it possible to extract the core informational and educational value.

Finally, managing the complex, multi-step process of video comprehension, translation, and content generation requires a sophisticated workflow. Multi-Agent Systems (MAS) provide a robust framework for such tasks [1 , 15] In a MAS, complex problems are decomposed and distributed among specialized, autonomous agents that collaborate to achieve a common goal. This paradigm is particularly suited for dynamic and unpredictable tasks, like research and information synthesis, where a fixed, linear pipeline would be inadequate. By having agents for comprehension, validation, translation, and synthesis, a system can be made flexible, scalable, and robust [12 , 17] .

Our research builds upon these distinct fields by integrating them into a cohesive system. We leverage multimodal AI for deep video comprehension, apply educational AI principles for quiz generation, and use a multi-agent framework to orchestrate the entire process, all with the specific goal of overcoming the linguistic and contextual barriers that fragment agricultural knowledge.

Methodology: Agentic approach to Multimodal Content Transformation

The core of our solution is a Multi-Agent AI system that orchestrates a series of complex tasks to transform multimodal content. By combining multiple specialized agents, we can break down the complex challenge of content transformation into manageable sub-tasks. This modular approach, facilitated by frameworks like the Google Agent Development Kit (ADK), allows for dynamic planning and execution, where agents can collaborate to achieve a common objective.

Our Multi-Agent system for transforming farmer videos is designed around a sequence of comprehension, validation, and synthesis tasks, each handled by one or more specialized agents

Orchestrator Agent: This agent oversees the entire workflow. It initiates the process, passes the output of one agent to the next, and ensures the seamless execution of the overall task. The orchestrator can dynamically plan the sequence of agent actions based on the specific input video and the desired output format. This agent employs the following agents.

Comprehension Agent: This agent is responsible for the initial analysis of the input video. Leveraging a multimodal AI model, it can process the audio, visual, and textual information (if available) in the video. The agent's primary goal is to extract the key agricultural concepts, techniques, and the sequence of actions being demonstrated. It identifies the core knowledge being shared by the farmer in the video.

Knowledge Validation and Enrichment Agent: To ensure the accuracy and relevance of the extracted information, this agent is tasked with cross-referencing the comprehended knowledge with a curated knowledge base.

Translation and Localization Agent: This agent addresses the primary barrier of language. It takes the validated knowledge and translates it into the target language.

Content Synthesis Agent: This agent is responsible for generating new, easy-to-understand educational materials from the translated knowledge.

Article Generation: It can synthesize an illustrated article that summarizes the key steps of the agricultural practice. It can select representative still images from the original video and even generate new illustrative images to accompany the text, making the information accessible even to farmers with lower literacy levels.

Quiz Generation: To reinforce learning and assess comprehension, this agent can generate interactive quizzes with multiple-choice questions based on the transformed content.

Implementation: How it works: Illustration of end-user scenario

1. A user uploads a farmer-to-farmer video in a specific language (e.g., a video in Hindi about a regenerative agriculture technique).
2. The **Orchestrator Agent** initiates the process, passing the video to the **Comprehension Agent**.
3. The **Comprehension Agent**, powered by Gemini, analyzes the video and extracts the key steps and concepts.
4. This extracted information is then passed to the **Knowledge Validation**.
5. The validated knowledge is sent to the **Translation and Localization Agent**, which translates it into the target language.
6. Finally, the **Content Synthesis Agent** receives the translated information and, using Gemini, generates two outputs:
    - A simple, illustrated article with images extracted from the video.
    - An interactive quiz with multiple-choice questions in Swahili.
7. These generated materials are then made available to the farmer in Africa, effectively breaking down the barriers of language and geography.

A demonstration of this system can be viewed at: https://sites.google.com/view/ai-multimodal-sharing-agri/

Results

Our experimentation with the developed Multi-Agent AI system demonstrates its capability to dynamically transform multimodal agricultural video content into accessible educational materials. The system successfully takes an input video on sustainable or regenerative agricultural practices and generates a concise, easy-to-understand capsule containing new text and images that represent the original content. This aligns with the growing application of AI in promoting regenerative agriculture by making complex information more accessible.

The system's ability to plan and assemble a dynamic set of AI agents to strategize and execute multimodal content synthesis is a significant outcome. This dynamic planning allows the system to be flexible and adaptable to different types of input videos and user requirements. The process of comprehending, validating, and translating content across modalities showcases the power of a multi-agent approach in tackling complex, multi-step problems

A key output of our system is the generation of question-and-answer pairs in multiple languages. This feature directly addresses the need for knowledge verification and reasoning skill development among farmers. AI-powered quiz generation is an emerging field in digital education, and our application of it in the agricultural context shows significant promise for enhancing learning and retention of new farming techniques. The ability to provide these quizzes in local

languages further lowers the barrier to entry for farmers who may have limited formal education

By re-representing complex video content into a simplified format in native language, we are effectively enabling the cross-pollination of agricultural best practices. This directly tackles the challenge of information silos and the difficulties in disseminating knowledge across different cultural and linguistic groups.

A farmer in one part of the world can now conceptually understand and learn from the experiences of a farmer in a completely different region, fostering a global network of shared knowledge. This is especially critical as traditional farmer-to-farmer knowledge exchange, while effective, is often limited by geography and pre-existing social networks.

While the results are promising, it is important to acknowledge the challenges. The accuracy of the initial video comprehension is critical; any misinterpretation by the first agent can lead to incorrect information being propagated through the system. The quality of the translation and localization also depends heavily on the AI model's training data for specific agricultural terminologies in less common languages. Therefore, incorporating a human-in-the-loop mechanism for validation, especially in the initial stages of deployment, could be beneficial.

Conclusions & Future Directions

This research has demonstrated the development and capabilities of a Multi-Agent AI system for the cross-lingual and cross-modal transformation of agricultural knowledge. By leveraging the power of multimodal AI and agent-based architectures, our system successfully breaks down the significant barriers of language, literacy, and geography that have historically hindered the global sharing of farming best practices. The ability to take a farmer-to-farmer video in one language and dynamically generate simplified, illustrated articles and interactive quizzes in another language represents a significant step towards democratizing agricultural knowledge.

Our work confirms that a multi-agent approach, utilizing specialized agents for comprehension, validation, translation, and synthesis, provides a flexible and effective framework for this complex task. The implementation, using Google Gemini and the Google Agent Development Kit, showcases the potential of current AI technologies to create practical solutions for real-world challenges in the agricultural sector. The system not only facilitates learning but also enhances understanding and reasoning skills through features like automated quiz generation.

Future work will focus on several key areas to improve the system's robustness and impact. Firstly, we aim to enhance the knowledge validation process by integrating more extensive and diverse agricultural knowledge bases, including localized and indigenous knowledge systems. Secondly, we plan to improve the localization capabilities of the Translation Agent by fine-tuning the AI models on specific agricultural dialects and terminologies. Introducing a feedback loop, where farmers can rate the quality and relevance of the generated content, will be crucial for continuous improvement.

Furthermore, exploring the generation of other content formats, such as short animated videos or audio-only summaries for low-bandwidth environments, could further increase the accessibility of the information. Finally, conducting large-scale field studies with farming communities in different parts of the world will be essential to evaluate the real-world impact of this technology on the adoption of sustainable agricultural practices and to ensure that the AI tools are developed in a human-centered and culturally sensitive manner.

In conclusion, the Multi-Agent AI system presented in this paper offers a powerful new paradigm for global knowledge sharing in agriculture. By enabling farmers to learn from each other, regardless of language or location, we can accelerate the adoption of sustainable and regenerative practices, ultimately contributing to a more resilient and food-secure future.

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