Poster: Bridging IoT Gaps in Developing Regions with LLMs

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Abstract

We investigate the integration of Large Language Models (LLMs) with the IoT to address adoption challenges in developing regions. Despite IoT's potential to revolutionize sectors like agriculture and healthcare, its adoption in these regions is hampered by issues such as data complexity, interoperability, and language barriers. LLMs, with their ability to process natural language and simplify complex data, enable the translation of IoT data into understandable, actionable insights. Use cases in agriculture and healthcare illustrate the transformative potential of LLM-IoT integration and highlight the broad opportunities for enhancing societal well-being and economic development.

CCS Concepts

• Computer systems organization → Sensor networks; **• Human-centered computing → Accessibility technologies**; **• Computing methodologies → Natural language generation**.

Keywords

Internet of Things (IoT), Large Language Models (LLMs)

1 Introduction

IoT has emerged as a revolutionary force capable of transforming multiple sectors by enabling real-time data collection, monitoring, and decision-making. In sectors like agriculture and healthcare, IoT holds the promise of improving operational efficiency, optimizing resource management, and providing personalized insights for better decision-making. However, the adoption of IoT technologies in developing regions has been slow and fragmented due to several barriers, including infrastructure limitations, low digital literacy rates, and the complexity of the data.

These challenges are particularly pronounced in developing regions, where access to technology is often limited and where diverse linguistic and socio-economic contexts make it difficult to deploy uniform solutions. Farmers, for instance, often lack the training to interpret complex agricultural data from IoT devices, while patients in under-resourced healthcare systems may not understand health data presented in technical language. Such barriers prevent the full realization of IoT's potential in enhancing societal well-being and economic growth in these region.

LLMs offer a powerful solution to these challenges. Capable of understanding and generating natural language, LLMs can bridge the gap between complex IoT data and non-technical end users by simplifying data into actionable insightsLLMs [2]. Through conversational interfaces and translation into local languages, LLMs can make IoT technology more accessible to a broad user base. This paper explores two crucial sectors—agriculture and healthcare—where the integration of LLMs and IoT can have a transformative impact.

2 Use Case: Agriculture

Agriculture remains the backbone of the economy in many developing countries, providing livelihoods for millions [1]. However, traditional farming methods often result in inefficiencies, limited yields, and significant resource waste. IoT technology has the potential to change this by providing farmers with real-time data on soil moisture, nutrient content, and environmental conditions, enabling more precise resource management. Despite this potential, IoT adoption in agriculture is limited due to the complexity of interpreting IoT data and the lack of technical expertise among farmers.

By integrating LLMs with IoT data, this barrier can be overcome as shown in Figure 1. LLMs can take raw data from IoT sensors and generate actionable recommendations tailored to each farmer's specific context. For example, if a farmer's IoT system detects that soil moisture is low, the LLM can analyze local weather forecasts and suggest the optimal time for irrigation, while also providing advice on how much water to use to avoid waste.

Moreover, LLMs can help aggregate and interpret data from multiple sources, such as market trends, pest outbreaks, and weather forecasts, giving farmers a comprehensive view of the factors influencing crop success. For example, during a pest outbreak, an LLM can notify farmers about the potential threat and recommend preventive measures. This capability is especially crucial in regions where farmers often lack timely and relevant information. In our preliminary evaluation comparing different LLM models, as shown in Figure 2, GPT-4o outperforms other models in predicting ideal crops, demonstrating the potential of LLM-IoT integration to enhance agricultural productivity and decision-making.

2.1 Use Case: Healthcare

The healthcare sector in developing regions faces similar challenges, with IoT devices offering immense potential for monitoring and improving health outcomes. However, the complexity of the data limit their adoption among the populations that could benefit most. LLMs can significantly lower these barriers by simplifying complex health data into easily understandable insights. For example, rather than presenting users with a detailed breakdown of their vital statistics, an LLM can summarize the key takeaways, such as whether their heart rate or blood pressure is within a healthy range. Additionally, if a patient's data shows concerning signs, such as a

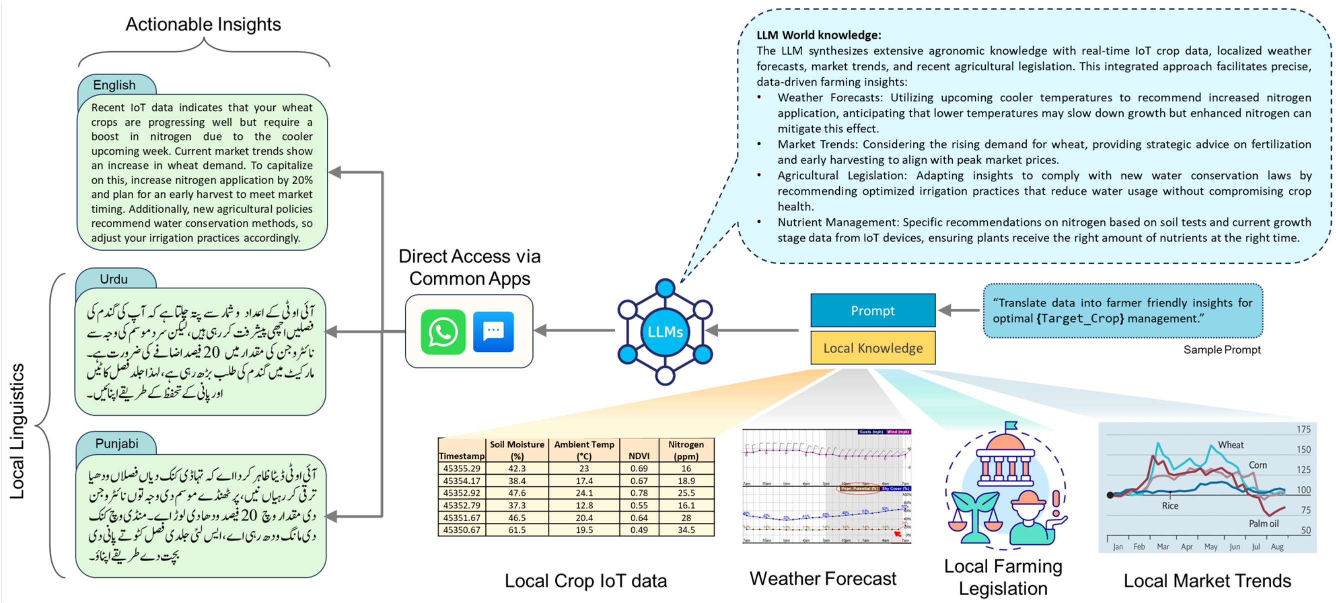

Figure 1: LLMs transform complex IoT sensor data into actionable agricultural insights for local farmers.

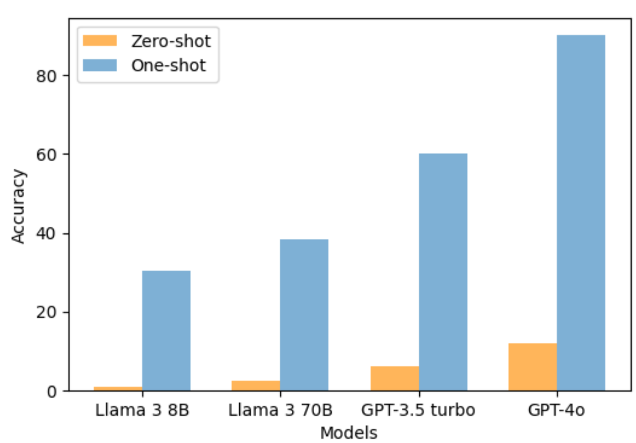

Figure 2: Performance of Llama 8B, Llama 70B, Chat-GPT3.5, and Chat-GPT4o when predicting the ideal crop to grow given certain conditions. Performance is shown in both the zero-shot and one-shot settings.

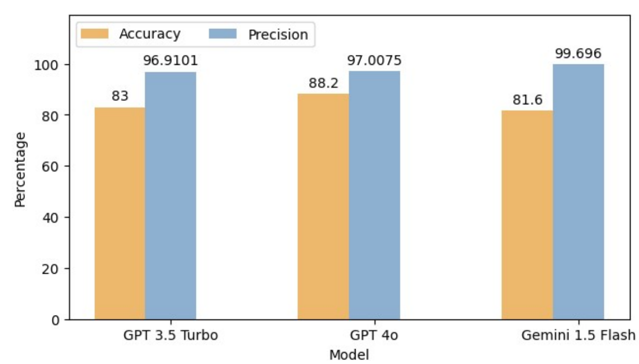

Figure 3: Accuracy and precision scores of Chat-GPT 3.5 Turbo, Chat-GPT 4o and Gemini 1.5 Flash in predicting the infection status of COVID-19 patients in a zero-shot setting.

sudden drop in oxygen levels, the LLM can issue an alert and recommend seeking medical attention. These insights can be delivered in the user's local language via familiar communication channels like SMS or WhatsApp, ensuring that even elderly patients with limited technical skills can benefit from IoT health monitoring.

Beyond individual patients, LLMs can assist healthcare providers by aggregating data from multiple patients and generating population-level insights. For example, during a health crisis such as the COVID-19 pandemic, IoT devices could monitor the vitals of infected individuals, and LLMs could analyze the aggregated data to identify trends and recommend interventions, as shown in Figure 3. This capability could prove especially useful in regions where healthcare infrastructure is underdeveloped and resources are scarce. By enabling more efficient use of IoT data, LLMs can improve both individual patient care and public health outcomes.

References

[1] A. Azam and M. Shafique. Agriculture in pakistan and its impact on economy. *A Review. Inter. J. Adv. Sci. Technol*, 103:47–60, 2017.

[2] J. Yang et al. Harnessing the power of llms in practice: A survey on chatgpt and beyond. *ACM Transactions on Knowledge Discovery from Data*, 2023.