Satellite imagery and AI to improve living conditions in refugee camps around the world with special focus on Water, Sanitation and Hygiene (WASH)

Abstract

Refugee camps, which accommodate a staggering 108.4 million forcibly displaced individuals worldwide, encounter significant obstacles in delivering adequate Water, Sanitation, and Hygiene (WASH) facilities. This paper delves into the integration of Artificial Intelligence (AI) and high-resolution satellite imagery as a means to tackle WASH-related issues present in refugee camps. The overcrowded conditions prevailing in these camps contribute to scarcities in crucial resources, thereby exacerbating health hazards for the inhabitants.

The review of existing literature sheds light on the diverse applications of AI, ranging from humanitarian logistics to agriculture, as well as its utilization in mapping poverty and infrastructure using satellite imagery. This study proposes harnessing the potential of AI to analyze satellite imagery, enabling the identification of structures within refugee camps in terms of WASH provision. By generating a training dataset, machine learning algorithms can be developed to detect and quantify these structures, thereby facilitating targeted interventions to alleviate overcrowding and enhance accessibility to WASH facilities.

The research acknowledges previous studies that have measured WASH-related challenges in refugee camps, emphasizing the necessity for AI-driven proxies to enhance the collection of data in dynamic and densely populated settlements. The suggested solution underscores the unique opportunities offered by space technologies for data acquisition in informal settlements, presenting a fresh and innovative approach to bolster WASH conditions within refugee camps.

The paper concludes by emphasizing the advancements made in image classification algorithms, particularly the utilization of pre-trained Convolutional Neural Network (CNN) models, and their applicability to WASH conditions within refugee camps. The employment of deep learning techniques, in conjunction with satellite imagery, demonstrates the potential for AI to play a pivotal role in ameliorating WASH conditions within refugee camps, thereby offering a distinctive and efficient means to address critical humanitarian challenges.

Key words: Enhancing Water, Sanitation, and Hygiene (WASH) Conditions in Refugee camps Through Artificial Intelligence and Satellite Imagery

Introduction

Refugee camps are temporary installations constructed to provide immediate assistance and safeguard to individuals who have been compelled to vacate their residences due to violent acts, conflicts, or persecution. As of the conclusion of 2022, there are more than 150 refugee camps worldwide, accommodating over 108.4 million people who have been forcibly displaced as a result

of persecution, conflicts, violence, or violations of human rights. This figure surpasses the population of Germany.[1] Within these camps, refugees encounter hardships such as hunger, language barriers, unemployment, and limited access to medical care.[2] Owing to insufficient available resources and dense living conditions, the Water, Sanitation, and Hygiene (WASH) standards in refugee camps frequently fall below fundamental requirements.[3] Consequently, refugees, predominantly women and girls, are often compelled to spend extensive hours daily traveling long distances or queueing at handpumps or tap stands in order to procure water.[4] This situation diminishes their available time for education, livelihoods, or other pursuits.

The overcrowding that is prevalent in almost all refugee camps exerts immense pressure on the infrastructure and resources, resulting in the scarcity of critical provisions such as clean water, food, and medicine. The absence of clean water exposes these refugees to numerous diseases and infections.[5] This research article examines the utilization of Artificial Intelligence (AI) as a means to address WASH issues through the utilization of high-resolution satellite imagery to label significant structures in refugee camps, including tents and permanent constructions. This approach allows for the identification of gaps in the provision of toilets, water facilities, and waste collection points. By generating a training dataset, a machine learning algorithm can be developed to identify and enumerate these structures, thereby enabling the implementation of decongestion interventions to ensure improved accessibility for WASH facilities.

Literature review

Artificial Intelligence (AI) has been used in myriad ways in this modern world to address and improve the living conditions of billions. AI is increasingly being used to aid humanitarian response efforts. AI technology can improve sustainable humanitarian logistics (SHL) by utilizing faster computational capabilities, data, and innovative algorithms. AI-based logistics and supply chain tools are already in use in non-profit organizations, and AI can assist SHL in saving lives during disasters while embracing sustainability (Bullock & Oroz, 2022). AI has also revolutionized agriculture by improving farming practices, detecting diseases, predicting crop yields, and identifying areas prone to scarcity (Mhlanga, 2020).

Artificial intelligence and satellite imagery are being used to map locations for poverty and infrastructure. High-resolution satellite imagery combined with machine learning has proven useful in tasks such as poverty prediction, infrastructure measurement, and forest monitoring (Kumar, 2020). Deep learning approaches, specifically convolutional neural networks (CNN), have been applied to predict the percentage of poverty using satellite imagery data (Kasiful, 2022). These models extract features from the images, such as night-time light data, and correlate them with poverty levels (Shweta, 2023). Additionally, deep learning methods have been used to automatically detect electric transmission infrastructure from aerial imagery, aiding in efficient planning for

[1] https://www.unrefugees.org/news/refugee-camps-explained/#Whatisarefugeecamp?
[2] https://www.unrefugees.org/refugee-facts/statistics/
[3] https://www.wfpusa.org/articles/hunger-largest-refugee-camps-world/
[4] https://www.unhcr.org/what-we-do/protect-human-rights/public-health/water-sanitation-and-hygiene
[5] https://www.unrefugees.org/news/usa-for-unhcr-launches-satellite-imagery-and-crowdsourcing-project-to-improve-refugee-camp-planning-and-maintenance/

electricity access (Wei, 2020). By analyzing satellite photos taken during both day and night, deep learning models can identify economic activity and use it as a measure of poverty, providing a practical and affordable means to collect data about poverty levels (D., 2023).

Developing proxies using AI to measure water and sanitation issues in refugee camps is an important area of research. Few papers have addressed this topic. Tsesmelis et al. propose the development and implementation of a WASH related Composite Index to facilitate assessments in refugee camps (Demetrios, 2020). Harding et al. adapted and implemented Lot Quality Assurance Sampling (LQAS) survey design in a refugee camp to measure WASH indicators and prioritize areas for intervention (Elizabeth, 2017). Calderón-Villarreal et al. conducted a cross-sectional study analyzing WASH access in refugee camps, including menstrual health services, and identified large inequalities across social and geographic stratifiers (Alhelí, 2022). Akhter et al. conducted an exploratory study in Rohingya refugee camps to identify drinking water security challenges and provide insights for sustainable interventions (Mehereen, 2020). Arétouyap et al. assessed the living conditions of refugees in a camp and found that some WASH standards were met, but there were concerns regarding queuing time, sanitation facilities, and waste management (Zakari, 2016). These papers provide valuable insights into the measurement and assessment of water and sanitation issues in refugee camps, but further research is needed to explore the potential of AI and especially satellite image classification in developing proxies for this purpose.

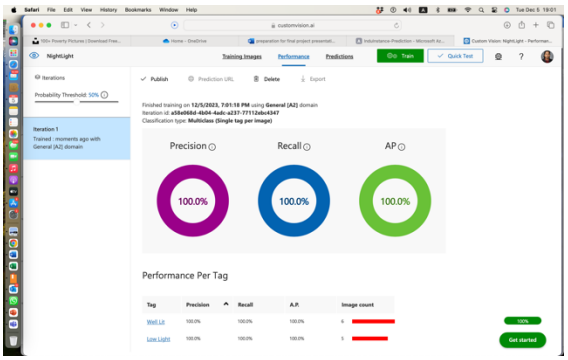
Proposed solutions

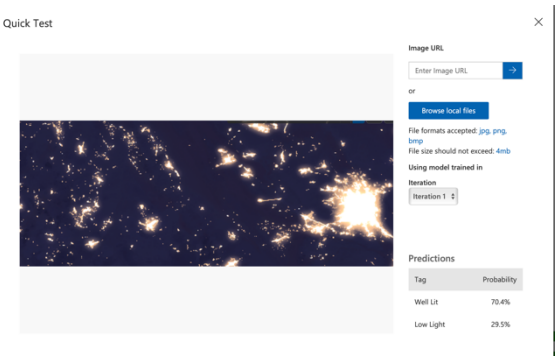
There are limitations in gathering data in informal settlements, refugee camps, partly because of the time constraints and the dynamic and dense characteristics of these settlements. Thus, the utilization of space technologies (Satellite imagery) presents unparalleled prospects for acquiring data that can enhance access to water, sanitation, and hygiene (WASH) in informal settlements. (Julia Dickson-Gomez 1, 2023).

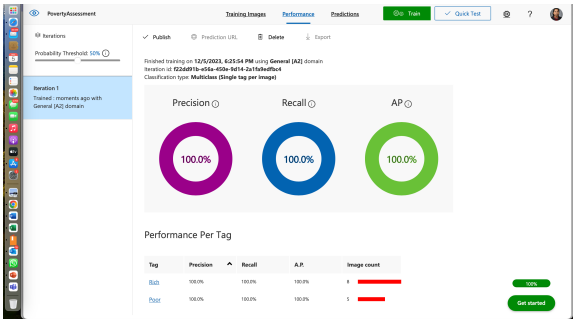
Satellite imagery coupled with other available data could be used to identify WASH needs and design interventions. The AI algorithms assist humanitarian aid agencies and governments alike. A variety of tools, including hydrological analysis, landcover, and elevation maps, can be obtained through the utilization of satellite imagery. These tools and the capability of AI play a crucial role in the initial stage of settlement planning as they enable the assessment of a location's susceptibility to specific hazards and facilitate the creation of timely strategies to mitigate such hazards. Additionally, inquiries concerning drainage are of utmost importance in order to effectively design and equip refugee camps.

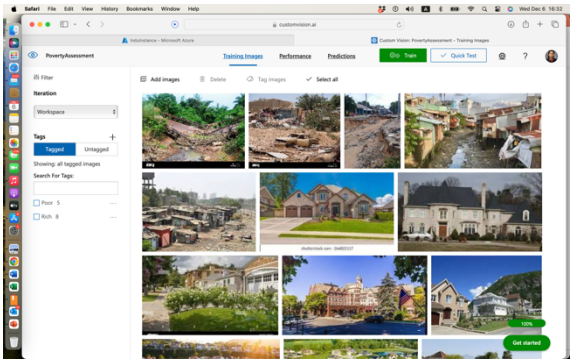
Experiment

A sample of images were downloaded from internet to conduct a preliminary image classification using Microsoft Azure’s Custom Classification and the results are depicted below.









As can be seen above, the accuracy and precision levels in classifying night light satellite images and classifying images to assess poverty levels has been very high from the experiment. Testing accuracy has also been above 98% for poverty assessment and above 75% for night light classification. These preliminary results provide immense potential for humanitarian aid agencies to design interventions to improve living conditions in refugee camps.

Conclusion

The accuracy of image classification algorithms has significantly improved with the use of pre-trained Convolutional Neural Network (CNN) models (Jaya, 2023). These pre-trained models have advanced the field of image classification and have been shown to perform well in diverse image classification tasks (Voruganti, 2022) . Deep learning approaches, such as using pre-trained DCNN models, have advantages over traditional machine learning approaches and have applications in various domains, including medical image classification. Deep learning-based image classification techniques, in general, provide enhanced accuracy and possess a diverse array of advantages across various domains. By expanding the existing body of evidence on the utilization of satellite imagery for poverty mitigation interventions, advancements in agricultural practices and planning electricity interventions for instance, it can be asserted that artificial intelligence (AI) image classification tools hold the utmost potential to aid in the amelioration of Water, Sanitation, and Hygiene (WASH) conditions within refugee camps.

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