

WEEKLY RESEARCH SEMINAR PRESENTATION

Enhancing Crop Type Classification in Smallholder Farms: integrating spatial-temporal features with LSTM-MLP



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ABSTRACT

Food insecurity remains a critical challenge in Rwanda, as evidenced by a 32% stunting rate and a 36% prevalence of child anemia. This widespread malnutrition is especially pronounced in rural areas, where 70% of the workforce depends on small-scale farming. Improving crop yields remains a government priority to improve nutritional outcomes. For example, Rwanda's Vision 2050 emphasizes the scaled-up use of modern inputs and technologies to boost productivity. For effective implementation of this long-term aspiration requires productivity monitoring and evaluation at farm level throughout the growing season to enable early warning of crop failure and timely, cost-effective agricultural interventions. Earth observation satellite images at various resolutions, combined with machine learning (ML) algorithms, provide a viable alternative for collecting agricultural information. However, the complexity of smallholder agriculture in Rwanda—characterized by fragmented landscapes, intercropping practices, and plots averaging 0.1-0.5 hectares—makes accurate crop monitoring essential yet challenging. Traditional ML methods such as random forest and multilayer perceptron (MLP) often falter in crop identification because they fail to capture the critical spatial and temporal features that underpin crop behavior. In contrast, CNN-LSTM models excel in crop type classification by effectively learning these spatial-temporal signatures. But collecting representative training data across such diverse agricultural landscapes remains prohibitively expensive and burdensome. To address this, we propose LSTM-MLP, a hybrid model that combines LSTM and MLP architectures. Unlike CNN-based approaches that require extensive annotated data, our framework leverages Haralick features to capture spatial signatures, integrating them with other relevant features to achieve accurate crop classification with limited training data. Using PlanetScope imagery and drone-based ground truth data from two Rwandan villages during the 2018/2019 agricultural season, we evaluated LSTM-MLP against standard MLP across three scenarios: i) spectral bands with radiometric indices, ii) spectral bands with Haralick features, and iii) all features including elevation. LSTM-MLP achieved superior F1-scores (91%, 91%, 93%, respectively) compared to MLP (87%-91%), with spatial feature integration significantly improving classification accuracy. This methodology demonstrates strong potential for scaling agricultural monitoring in resource-constrained regions, enabling more targeted and effective food security interventions through improved crop mapping.

Keywords: Crop-type mapping, Machine learning, PlanetScope images, and Smallholder farms

27 June
2025

10:30 AM - Kigali,
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WEEKLY RESEARCH SEMINAR PRESENTATION

IRS-ASSISTED WIDEBAND TERAHERTZ COMMUNICATION SYSTEM: BEAM TRAINING WITH EMPHASIS ON LARGE ANTENNA TRANSMITTER UNIFORM CYLINDRICAL ARRAY.



ABSTRACT

The rapid advancements in terahertz (THz) communication systems promise unprecedented data rates and support for bandwidth-intensive applications. To achieve this, terahertz frequencies are being explored. However, due to the high frequency of THz band, the THz signals suffer from a severe pathloss, which limits the coverage of the THz signals. Greater attenuation occurs when terahertz signals are blocked by obstacles such as buildings, walls and trees. Intelligent Reflecting Surfaces (IRS) have emerged as a transformative technology to enhance communication reliability, spectral efficiency and coverage in THz communication systems. Beam training is essential for ensuring efficient, high quality and reliable connections, especially in advanced systems like mmWave and THz communications. However, effective beam training in IRS-assisted wideband terahertz communication; a critical component for achieving high-performance communication, remains a significant challenge especially in scenarios utilizing in wideband terahertz large antennas such as cylindrical and spherical antenna arrays. While prior research has extensively explored beam training techniques for single antenna and Uniform Rectangular Array scenario in terahertz communication, the unique geometric and spatial properties of cylindrical antenna arrays are less explored. Wideband THz signals experience severe path loss and frequency-dependent beam split effects, further complicating accurate beam alignment. Existing beam training algorithms are not optimized for IRS-assisted systems with cylindrical array configurations, leading to suboptimal performance in real-world applications. Prior works mostly suffer from performance degradation due to the beam split in wideband terahertz communications. However, an existing framework called analytical beam training framework took an advantage of the beam split in the wideband terahertz communication but did not extend it to Large Antenna Transmitter Cylindrical Array and Spherical Array. I therefore extended this framework to Large Antenna Transmitter Cylindrical Array and the results shows significant improvement as compared to other frameworks.

Keywords: Beam training, Terahertz communication, Intelligent Reflecting Surface, Wideband, Cylindrical Array.

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