Research Summary

Alexander Metzger

Introduction. Information and Communications Technologies for Development (ICT4D) is about making digital technologies accessible to everyone to promote social and economic growth in developing countries. It is multidisciplinary and involves mobile phones, computer networks, satellite systems, internet protocols, embedded systems, and Human Computer Interaction. I take special interest in applying algorithm design, Machine Learning, and mobile network technologies to aid environmental sustainability and agricultural economic development.

eKichabi v2. Smallholder farmers in Sub-Saharan Africa lack accessible networking platforms which makes them reliant on middlemen to sell their produce. Our team at the ICTD Lab worked with collaborators to collect the largest agricultural phone directory to date. A big challenge was making the digital directory accessible to users with limited access to the internet or smartphones. To address this, I helped develop and maintain a USSD (Unstructured Supplementary Service Data) application, which allowed users to access the directory through basic mobile phones.

My specific role involved designing a custom binary protocol and compressi scheme to optimize usage logging for the study, a crucial feature given the high cost of mobile data in Tanzania. I took an active part in designing and improving the search fl for farmers based on two user pilots. I also solved a potentially study breaking issue of outdated data by developing a second USSD application to update information in our directory. My main contribution was scaling our USSD application by more than 7000x. This was a crucial step towards demonstrating the production readiness of the approach and work towards turning it into a long-term government run project. Co-first-authori the paper published at ACM SIGCHI 2024 with my mentor Ananditha Raghunath, I also performed statistical tests and created plots. I was invited to present the findings at t Para.chi DUB and the CHANGE seminar.

Farmer.CHAT. Smallholder farmers also lack access to trustworthy sources to teach sustainable farming practices and resolve issues like crop disease. Continuing my research with mobile technologies, I worked with Gooey.AI and our collaborators to develop and deploy retrieval augmented systems to assist extension workers across Kenya, India, Ethiopia, and Rwanda. The workflows are now used by 10s of millions of farmers and ha increased the affordability and reach of extension efforts by 100x. This work was featured by NVIDIA, OpenAI, and presented at the UN General Assembly.

The biggest challenge was handling low-resource languages where data is

scarce and foundation models lack relevant training. I organized efforts with partners to collect domain specific datasets and train translation and language models. I came up with custom glossary system to constrain models to specific meanings of non-English wor based on context. I also pushed for support in regions without smartphone/WiFi access and developed an Interactive Voice Response integration to allow phone users to call into a verbal LLM conversation to retrieve their information.

SAMIR. The problem of environmentally sustainable decision-making applies not just to farmers but to consumers of electronic products at large. Traditional life-cycle assessments (LCAs) require domain experts and proprietary databases. Using a multimodal information retrieval approach, we were able to create a set of algorithms to automatically estimate LCAs within an average of 11% of expert verified values leading to a user study consensus that the tool is accurate and trustworthy.

I was actively involved in user study design and third-authored the paper submitted to MobiSys 2025. I identified a lack of human-vetted but machine-parseab environmental footprint datasets in literature. I thus laid the groundwork for our evaluation and model training by parsing unstructured environment reports and online spec sheets into an environmental footprint database of over 500 products. All radio-capable technology is required to have an FCC report which would be a treasure trove of information if they were not unstructured poorly scanned documents and unlabeled images. To remedy this, I designed a computer vision algorithm to parse these into a machine readable format. The approach is extensible and will enable future work to tap into previously inaccessible data sources. It has the potential to be adopted by regulatory bodies to make environmental impact information directly accessible to consumers.

Conclusion. A recurrent theme in my research is use of algorithm design and mobile technology to offset gaps in information access for underserved languages/communities. I'm continuing this work at Dr. Shwetak Patel's UbiComp Lab and with my own research focused startup, Koel Labs. Funded by Mozilla and cloud credits, we are making language learning accessible so non-native speakers can interact with information and communities across language barriers.