
Exploring Potentials Sensor-Based Technologies in Kenyan Rural Homes

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About the Author

I am George Hope Chidziwasono, a final year Human Computer Interaction master's student in the department of Media and Information at Michigan State University. I will enroll in a PhD program in Information and Media at Michigan State University in fall 2018. I am a holder of BSc. in Computer Science and Physics from University of Malawi, Chancellor College.

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My research interests spans across three fields: Human Computer Interaction (HCI), Information and Communication Technology for Development and Computer Science. Specifically, I am interested in research that relates to application of sensor-based technologies in resource poor settings like rural Kenya and Malawi. Recently, I developed a sensor-based technology probe with the aim of exploring domestic security in rural Kenya. The probe consisted of a sensor that detects movement and send a message to participant's mobile phones. I used the data I collected to write my master's thesis and wrote a paper that was accepted for presentation and publication at CHI 2018 in Montreal. I intend to extend this project into my PhD research by incorporating participants' reflections in my future research

During the past two years, I have been working as a research assistant for Dr. Susan Wyche focusing on

HCI4D and ICTD. Through this assistantship, I have participated on different research projects in rural Kenya including use of solar power and everyday sustainable practices in rural Kenyan households and also exploring how rural Kenyan communities reuse, repair and breakdown materials.

Research Context and Motivation

My research is motivated by growing challenges that impede long term use of sensor-based technologies in African rural households. Growing up in Africa, I have experiences of some of the challenges that should be addressed to ensure successful use of technology in the home. Among others, these challenges include intermittent power failures, high percentage of population that is off-grid, poor Internet connectivity and cultural beliefs [22].

Despite these challenges, the exponential growth of mobile phone adoption in rural African homes like rural Kenya can be taken as a stepping stone to integrate sensor-based technologies in rural homes [22]. My research is driven by the growing interest of using technology in rural African households which foretells that there is a potential of adopting sensor-based systems to advance the standards of living in rural African homes. Through this existing potential, my research aims at understanding different patterns in rural African communities that would inform the design of sensor-based systems to suit their conditions.

Research goals

The goals of my research include the following:

1. To understand better ways of integrating sensor-based systems with mobile applications

that are widely used in developing countries like mobile money and SMS based text messages

2. To explore unexpected outcomes of deploying sensor-based systems in rural Kenyan households that will inspire the design of applications that can be used successfully in African rural homes.
3. To engage Kenyan rural residents in the process of designing sensor-based systems for household use
4. To explore constraints that might be encountered in using sensor-based technologies systems in Kenyan rural households

State of the art in terms of prior research?

Sensor-based technologies are providing new ways to augment human interactions with materials [20]. Findings from prior research suggest that new applications based on sensors have improved the way of life: networks to support agricultural production [14], sensing systems for real world applications in health [3,10,11,26,27], embedded chips on appliances like kettles to support communication among family and friends in the UK [2] and sensor-based technologies for learning about outdoor environments [19].

Within HCI and Ubicomp there have been numerous studies that have focused on sensor-based technologies [4–6,13,17]. For example, through the Aware Home Research Initiative, Kientz et al. evaluated user

experiences with sensor-based applications in order to develop applications that solve users' needs in the home [17]. This is one of the leading examples of research activities that focus on sensor-based research in the home. Through this project, it was proposed that the design of smart home applications should start with gathering requirements from inhabitants of the homes through formative methods. Crabtree and Tolmie explored how non-digital materials in the home can be incorporated with digital materials. With sensors, almost everything can be connected to a network thus looking at things that have not been made digital is very important [6].

Home sensor-based systems have been designed [15] mostly rely on broadband internet services to provide feedback to users whenever crime is detected [15]. As such, this only works better in areas where broadband Internet services are highly available. In areas like rural Kenya, it would be difficult to use Internet based home security systems due to poor connectivity [22]. A review of prior work on sensors for security suggests that sensor-based system that would work on GSM network were only used for research purposes [15].

Research investigating sensor-based technologies in developing regions are few, despite their potential for addressing problems. However there are exceptions. For example sensors have been used to; protect cattle from theft [19] and track goods on transit using GPS [7]. For instance, RFID based sensors have been used to track export cargo from factories to the frontier offices. A great impact in reducing diversion of goods in transits was realized after using RFID technologies [23]. Additionally, in Kenya there have been substantial advances where sensors are attached to animals in

order to track their movement. Sensor-based technologies can be used in rural areas where livestock are free range. Sensors would be used in this case in order to track livestock thereby keeping them within their grazing area [8]. This is very important for a small scale farmer in developing countries because other than cattle, most the animals in those regions are free range. As such, once a livestock has been stolen, it can be easily tracked [1].

Mainly, the use of sensors in most developing regions have been realized at institutional level rather than at household level. For example, in agriculture sensors have been deployed in Africa to improve agricultural products. Masinde et al. described how the adoption of mobile phones and wireless sensor-based technologies are being used in Africa to provide immediate weather information to farmers [21]. Their findings revealed that local collection of weather data using sensors provide a better way of delivering information to local communities through their mobile phones. The positive impact of this research on rural communities cannot be questioned however their approach did not provide a direct interaction between sensors and users. The sensors that collected weather data were not under the control of residents: residents were just recipients of weather information through their mobile phones. This approach has been used in many projects on sensors across Africa [12,25]. There is a need to deploy sensors directly in rural African households and understand how residents can interact with them and their impact.

Research approach

My research approach is mainly inductive which utilizes qualitative research methods that helps me to build trust and good rapport with participants; understand

general background of the area; and understand participants' experiences and reflections of the technology under investigation. Qualitative research methods that help me in achieving these goals include in-depth interviews, observations, field notes, technology probes, diary studies and follow-up interviews.

I use in-depth interviews and observations at the beginning of my study in order to understand my participants' background and establish a good rapport. Then I deploy a technology probe in participants' homes so that participants can experience how the system works and use it for different purposes in their households. I use technology probes because this approach combines the social science goal of collecting data, engineering goal of field testing products and a design goal of inspiring users and designers to think of new kinds of technology to support their needs and desires [16]. To fully understand participants' experiences during the time of deployment, I use diary studies that allow participants to record their daily experiences and reflections. This method helps me to collect data even when I am not available [24]. To ensure that participants are recording information on daily basis I provide them with guidelines to follow when recording information and I also send them incentives on weekly basis.

Finally, I use follow-up interviews at the end of the study. These interviews consist of some questions and probes that help me to understand participants' reflections of the system under study. Using these various methods helps me to validate data collected through data triangulation during analysis.

Findings

The use of a sensor-based home security system as a technology probe successfully worked as it prompted different reactions beyond my expectations.

Participants used the system for different purposes in their homes like monitoring their poultry as well as monitoring their family members. Additionally, the probe provoked participants to reflect about other application of sensors in their homes.

Findings from my previous research also suggested that sensor-based security system are important in fostering neighborhood cohesion in rural Kenyan households. For example, when our participants received alerts from the system while they are not at home, they called their neighbors to find out what is going on in their homes. This supports prior research that recommend use of technologies that support neighborhood cohesion to reduce burglary.

Unlike in industrialized countries where crime detection measures like alarms and cameras do not dissuade thieves [9], crime detection measures helps in deterring burglary in rural Kenya. From my prior study, participants consistently indicated that thieves are scared by measures that alert homeowners about theft like alarms and lights. For this reason, participants recommended that our next version of the probe should also include alarms and cameras.

Participants also had different experiences with the system during the four week course of deployment. Chronologically, these experiences consisted of moments of excitement, frustration, acceptance, and appreciation. Diary study entries suggested that at first participants were excited to have the system however

after a week participants experienced some frustrations due to charging problems and frequent alerts. During the last week of the study, participants found their way to overcome these challenges. For example to avoid frequent alerts they could only switch on the system when no one is at home or when they were going to sleep.

Research Status

Based on findings from my previous research, I am working on an improved version of the sensor-based technology probe I used last time. This system will be incorporated with new functionalities that will allow systems in the same neighborhood to communicate with each other in critical conditions thereby fostering neighborhood cohesion already existing measures like 'the Nyumba Kumi' (Swahili word for ten houses) project (for more about 'Nyumba Kumi' see [18]). Additionally, other features like alarms will be added to system based on participants' previous reflections and experiences. I will return to Kenya in summer 2018 with the improved version to understand how participants will experience it thereby extending this research.

Research Contributions

This project contributes to HCI by demonstrating the potential uses that sensor-based technologies can have for improving domestic security in rural Kenya. Beyond that, the use of this research also allows participants to reflect on other ways sensors can be useful in their homes. The technology probe's capacity in encouraging participants to think about other applications of sensors in their homes helped in opening more opportunities for further research related to sensors in rural Kenyan households.

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