Bringing Life Where There Is No Light: A Low-Cost Movie Projection and Data Collection Solution for Underserved Areas

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Abstract. Limited access to electricity in rural Africa impedes the human and economic development in these areas by restricting access to information. In addition, data collection in this region remains a costly and time consuming endeavor. However, recent developments in solar energy and the fast adoption of mobile phones present new opportunities to reach people living in African villages. In this paper, we present an innovative solution that combines a relatively inexpensive, solar-powered movie projection kit with a simple USSD based mobile application to provide entertainment in villages, while collecting data in a cost effective, real-time manner. The results from a pilot project in 8 villages where we deployed this solution highlight the possibility of obtaining detailed and instantaneous market data for advertisers, whilst simultaneously entertaining audiences with high quality content. We also discuss additional possible uses for the solution in other sectors such as health and education.

Keywords: ICT innovation · USSD · ICTD · M4D
Rural entertainment

1 Introduction

According to the World Bank, more than 82% of the populations living in rural Sub-Saharan Africa lack access to electricity [1]. While access to electricity is critical for many basic human activities, such as lighting, refrigeration, operating equipment, etc., the absence of electricity also impedes another important human need, namely access to information. This information is today perceived as crucial to human and economic development, and as having the ability to increase empowerment in rural areas through greater levels of community connectivity [3].

In spite of this challenge, countries in Sub-Saharan Africa have witnessed rapid growth in mobile phone subscriptions, which have climbed from a paltry 0.5% of the population in 2000 to 71.3% in 2016 according to data from the

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International Telecommunication Union (ITU). This mass adoption of mobile phones presents a major opportunity for access to Digital Media. At the same time, the development of a Digital Media industry in Africa, and in Rwanda in particular, is constrained by the limited number of distribution outlets. Indeed, according to the Demographic and Health Survey conducted by the National Institute of Statistics of Rwanda (NISR) in 2014 and 2015, only 10% of households in Rwanda owned TV sets. This number is even lower in rural areas, where only approximately 4% of households owned TV sets [6].

We attempted to address these challenges in two ways. First, we built a video projection kit that is robust, relatively inexpensive and powered by solar energy. Second, we developed a mobile application to collect feedback from viewers. This mobile application used the Unstructured Supplementary Service Data (USSD) communication technology in order to be accessible by virtually every mobile phone, including feature phones. In this paper, we present the results of a pilot study, called the "Village Mobile moVie (VMV)", that we conducted in 8 villages in Rwanda. Here, we projected movies using the video kit and collected feedback from viewers through the mobile application. We discuss the implications of these results and avenues for future work below.

2 Background

2.1 Media Distribution in Rural Rwanda

Rural Rwanda remains relatively disconnected from the mainstream audiovisual media distribution channels. For example, the government reported that in 2014 and 2015, only 4% of rural households owned a television set, whereas 52% owned a radio receiver [6]. This limited adoption of media receivers contributes to the isolation of rural dwellers as well as impeding the development of a local Digital Media industry. To address the low rate penetration of television sets, a small number of entrepreneurial people in rural communities may purchase television sets that they use as a sort of cinema, where people can watch movies and shows for a fee. However, the small sizes of the television sets offer poor viewing conditions to the relatively large audience, who require a big screen.

Other efforts to project movies in rural areas include the annual Rwanda Film Festival held in July, which uses a large inflatable screen and a professional projector powered by a diesel generator. Nonetheless, the high cost of the equipment used (around $\$30,000$ per kit) severely restricts the spread of this type of initiative in the country. Therefore, there is a need for a projection kit that is relatively inexpensive in order for it to be affordable to entrepreneurs in villages.

2.2 Unstructured Supplementary Service Data

Unstructured Supplementary Service Data (USSD) is a GSM communication method that enables fast exchange of text between a mobile phone and an application on the network. Unlike the Short Message Service (SMS), USSD is a

session-oriented service that provides "minimal delay between the sending and receiving of queries" [9]. These characteristics allow the creation of menu-based, interactive applications that can enrich the user's experience.

Perrier et al. argue that USSD is a better suited method for data collection in regards to ICTD [7]. Like voice and SMS, USSD is a universal service and is accessible from any phone as it is part of the GSM specifications. Data collection through SMS presents a number of constraints such as the requirement to send text in a specific format in order for it to be understood by an SMS application. This creates a need for external systems, such as paper-based systems, that support the creation of well-formatted SMS messages [10]). However, USSD improves the user's experience during data collection in a number of key ways. Firstly, it provides forms that guide the user. In addition, it removes the need for multiple messages when providing multiple answers. Finally, USSD allows for the immediate validation of data during the collection process.

These advantages have made USSD an effective platform for building mobile applications that can reach virtually every mobile phone user. They have also enabled it to be used in a number of different domains such as the health sector [5], mobile money services [4], and even in mobile crowdsourcing where workers are paid for completing tasks [2].

3 The VMV Projection Kit and USSD App

The setting of this study was 8 villages spread across three rural districts in Rwanda. The low electricity penetration and relatively high ownership of mobile phones (mostly feature phones) informed the requirements for the design of our system. Our proposed system combined a relatively inexpensive video projection kit with a USSD application for data collection (Fig. 3).

3.1 Movie Projection Kit

A key specification of the movie projection kit was its suitability for use in rural areas. To achieve this, we aimed to build a system that would (1) rely on solar energy for power; (2) be robust, small in size, and transportable; (3) be easy to assemble, without requiring significant training; and (4) be relatively inexpensive, with a total cost of $1,000 or less for all required hardware. We used an iterative design method, building prototypes, testing them and thereafter making changes.

The first prototype of the projection kit used solar energy and batteries that could support 2 to 3 h of operation (Fig. 1a). The entire system, including the solar panel and battery, one speaker with built-in amplifier, and a large custom-made screen met our initial target cost of $1,000, could fit in a standard travel bag and weighed approximately 35 Kg (Fig. 1b). However, this prototype was complex to build since we had to connect, and in some cases solder, all the components together. Hence, a significant amount of specialized labor was required to assemble the system, resulting in the prototype being neither robust

nor easy to set up. Moreover, the power of the single speaker was not enough for outside projections with a large audience.

(a) First kit prototype

(b) First prototype being transported

Fig. 1. First prototype of the projection kit

To build a more robust and easy to assemble system, we decided to use off-the-shelf components, particularly in terms of the solar energy equipment. Thus, our second prototype included a "pico" portable projector, two 800 W speakers, a complete solar power unit with solar panels and a battery, a microphone, and a custom made portable screen (7 m by 3 m) for a total cost of about $2,000. The battery could provide up to 3 h of continuous projection and could be charged in a day by the solar panels. Though this prototype went beyond our cost requirement, it was nonetheless more robust and required less effort to assemble.

3.2 USSD Application

We built a USSD application for data collection, choosing to use USSD over SMS for two main reasons. Firstly, USSD allowed us to keep the overall cost lower for our viewers as, unlike SMS, USSD sessions are free for users. Secondly, it allowed us to reduce incorrect and invalid data by using the interactive forms that USSD provides. This application also meant that viewers were not required to remember the short codes to dial as these were projected on the screen with the adverts. Additionally, prepaid customers of telecommunication providers were able to load airtime and check their available balance through USSD. Crucially, since more than 98% of the Rwandan mobile service subscribers are prepaid

customers [8], the vast majority of mobile phone users are familiar with using USSD applications.

Finally, our USSD application allowed the person in charge of a projection to register viewers by collecting the viewers' location (village name), age, gender, phone number and the household size. These data points allowed us to obtain basic demographics regarding our audience. We could then share this information with advertisers to give them a clearer understanding about their customers.

4 Movie Projection and USSD App Deployment

In March 2015, we projected movies in 8 villages in Rwanda, spread across three districts. We had initially planned to target 9 villages, however we had to cancel a show in one village due to heavy rains and a lack of access to an indoor facility. Similarly, we faced various other issues that impeded our data collection in two more villages. Therefore, we present the data obtained from the projections in six villages.

We selected these villages based on the presence of a market that attracts people from nearby villages. Indeed, we set our projection dates to coincide with market days so as to attract the maximum number of viewers. The movie projections were completed using our projection kit. We also built our own USSD application for data collection.

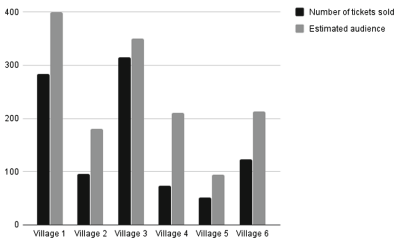

Fig. 2. Number of tickets sold vs estimated audience

We projected the movies in the evenings as our projector performed poorly in the daylight. During the day, our operatives visited the markets informing people of the upcoming movie projection. To pay the wages of the operatives, we charged RWF100 per ticket (about $0.12). However, since the projections were made in open areas, many more people watched the movies than had initially bought the tickets (see Fig. 2).

Prior to starting the movie projection, we asked the viewers to use our app to signal their presence in the audience. We projected the code they could dial (e.g., ∗868∗1#) to achieve this. This enabled us to know the approximate number of viewers who had access to a mobile phone, allowing us to compute the effectiveness of our data collection method. During the movie projection, we had a number of advert breaks, similar to a number of local TV stations. However, we limited the number of advert breaks to three in order to minimize interruptions. At the end of each advert, we asked questions which were projected on the screen regarding the viewers' feelings towards the advert and/or product advertised. For example, we projected messages such as: *dial* ∗868∗1∗1# *if you liked this advert or if you would buy this product. If you do not like this advert or product, dial* ∗868∗1∗2#. The first part of the code (868) represented our USSD

short code. The second part of the code identified the number of the question being asked. For example, 1 was used to indicate the first question, whereas 2 indicated the second question. The third and last part of the code identified the answer of the viewer. For example, 1 was used by the viewer to indicate approval of the advert or product. Those answers were sent via the cellular network to our server, where they could be monitored and analyzed in real-time using a web application (see Fig. 3). To encourage people to respond with their mobile phones, we informed them that there would be a random drawing of phone numbers that had responded to questions. The owners of these phones could then win various prizes including vouchers for phone airtime, various products from advertisers, local food and drinks.

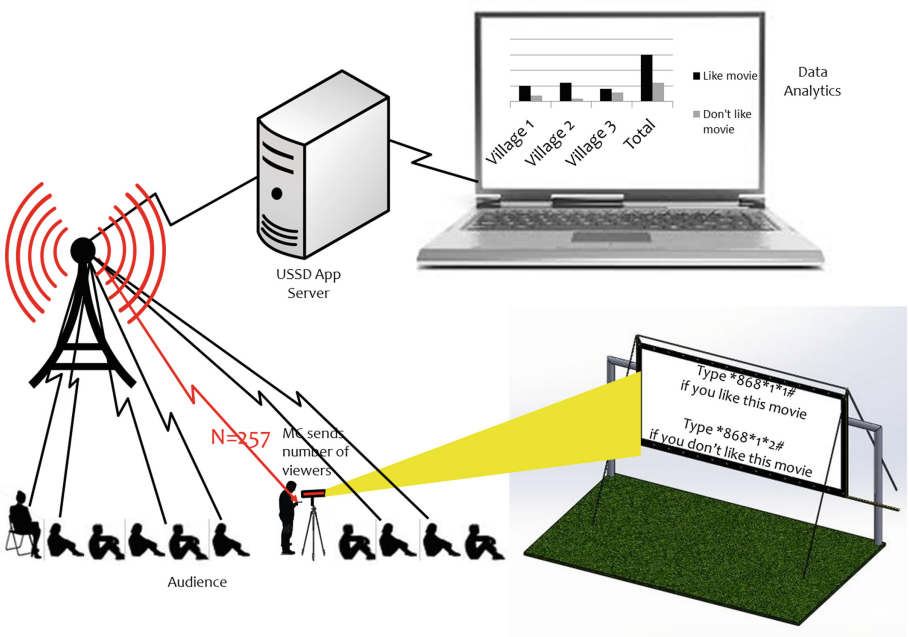

Fig. 3. System design, with video projection and USSD app

Figure 4 shows the average number of responses by projection to the question relating to audience presence and the three advert questions. This figure shows that the number of people answering questions gradually reduces over time. We posit that this may be due to a fatigue in answering questions. This reduction in the number of answers could also indicate a decrease in the number of people present, as we noticed that a number of women would leave the site early to go attend to house chores. However, we believe further research would need to be conducted in order to determine the ideal number of adverts. On one hand, possible viewer fatigue may reduce the optimum advertisement number,

on the other hand, it is likely that advertisers would like to ask viewers as many questions as possible.

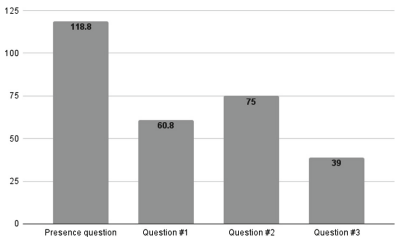

Fig. 4. Average number of answers per questions

Our system also enabled us to conduct simple experiments with adverts to determine which was best received by the audience. For example, one company had created two adverts for the same product and wanted to test their popularity with a real audience. We projected both adverts and asked the audience to text the number of their preferred advert. Figure 5 shows the result of this test.

The data analysis shows that, in general, the audience was more receptive of the second advert (Pub 2) than of the first advert (Pub 1). Women were more receptive than men; people aged 1–20 and 31–40 were less receptive; and people from smaller households (less than 9 people) were more receptive. More in-depth analysis could be obtained by combining our collected data with public economic and social data from the census for those particular villages, emphasizing the effectiveness and efficiency of our system.

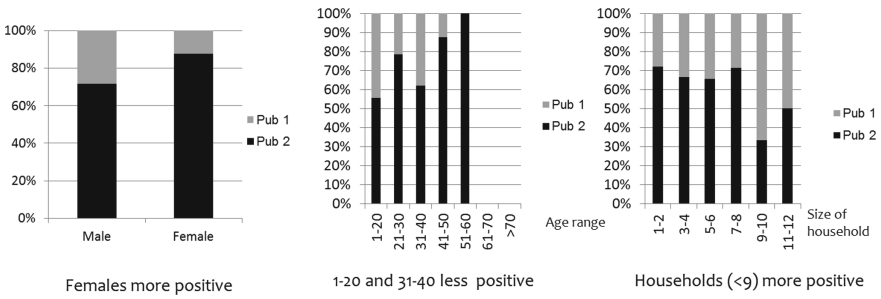

Fig. 5. Experimenting with two adverts

5 Discussion

In this paper, we have demonstrated how we can offer entertainment in remote parts of a developing country and collect data by using simple, low-cost technologies. We described how we built a robust and relatively inexpensive movie projection kit using off-the-shelf equipment. More importantly, we have highlighted how the use of solar energy to power the projection kit increased usability in remote Rwandan locations that do not have access to electricity. Additionally,

we have described how we created a custom-built application for data collection. The application used the Unstructured Supplementary Service Data (USSD) technology, making it accessible to virtually every mobile phone.

By using simple code displayed on the projection screen, our USSD application enabled the viewers to provide feedback to advertisers in an easy and speedy manner at a minimal cost. Therefore, the design of the USSD app enabled virtually any viewer with a mobile phone to provide quick feedback to advertisers allowing the latter to obtain an almost instantaneous picture of their target market's feelings towards their products.

The simplicity of the USSD app design makes it portable to other media as well. For example, advertisers could display similar short code on their TV ads, billboards and posters to receive real-time market insight regarding their products.

Additionally, the projection kit together with the USSD application provide a powerful method for reaching people who are otherwise outside the domain of mainstream audiovisual media. For example, it may be possible for governmental or non-governmental organizations to use the projection kit to educate people on relevant local issues, such as best practices in the health, or new agricultural techniques. After the training through video projection, the organizing entity could then ask questions to the audience and collect answers through the USSD app. In this way, the organization can get real-time feedback on the effectiveness of their training material.

6 Challenges and Conclusion

During the implementation of this project, we met with a number of challenges that we discuss below:

- **Obtaining locally-made films:**
  In order to make our viewers relate more with the movies projected and watch them longer, we sought locally-made movies. Indeed, our project showed the average number of responses to advert questions sent through the USSD application remained constant when locally-made movies were projected, but reduced when other foreign movies were projected. For this study, we secured two movies: a locally-made and a foreign-made movie that was translated into the local language. When the local movie was projected, the average number of responses to the last advert question was 61.6% of the responses to the presence question. This number dropped to only 35.8% when we projected the foreign movie, indicating that more people stayed longer to watch the locally-made movie and they remained engaged throughout the projection.

  However, we faced significant challenges when trying to procure locally-made movies as the Rwanda's movie industry is still in its infancy and the cost of films still prohibitive. With a large scale deployment of the movie kits across many villages, we could help foster the movie industry by providing a bigger audience. This would help bring down the movie cost.

- **Working with mobile service providers:**
  To implement the USSD application, we had to work with mobile service providers to leverage their network infrastructure. Partnering with these companies proved difficult as this study did not have the ability to generate significant revenue for them. Despite the fact that only one of the three telecommunication service providers agreed to work with us, it still took approximately five months to connect our application to their network. Fortunately, this provider was the dominant market player with more than 50% of mobile subscribers at the time. The other two companies did not officially refuse us the connection, but had pricing terms that were out of our budget.
- **Finding suitable rooms for projection:**
  Though we built our projection kit for the outdoor environment, sometimes strong weather conditions, such as rains and powerful winds required that we conduct our movie projection indoors. However, this proved difficult in a number of villages where there was not a room large enough to host all the viewers. Thus, we were at times forced to cancel some projections.
- **Local authorities were sometimes not supportive:**
  We learned from experience how important it was to contact local authorities in advance in order to explain the benefit of the project for their communities and obtain their buy-in.

Despite these challenges, this project was successful and demonstrated that a low-cost video projection kit, powered by solar energy, can be an effective media distribution channel. If distributed across thousands of villages and combined with an easy to use and simple mobile data collection application, this solution could revolutionize data collection and analysis in rural areas for advertisers in Africa.

Compared with traditional surveys that are costly, labor intensive, and time consuming, our solution offers an effective and more efficient approach to data collection with the following two main advantages:

- During in-person surveys, interviewees are sometimes influenced by the interviewer. By using our USSD application, this potential bias is removed as the user directly provides answers through their mobile phone, without revealing them to an interviewer.
- The answers are collected in real-time and can be analyzed automatically for quick information provision to the advertisers.

Our USSD application is more effective at collecting answers for closed-ended questions that give respondents a fixed set of options to choose from. Closed-ended response choices can be simple yes/no options, multiple choice options and rating scales options.

Finally, as the projection kit was to be used only in the evening on market days, the concept was to have the projection kit managed by the village school allowing them to use it to project educational videos during class time, thereby enabling the use of multimedia educational content in rural classrooms.

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