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A New Personalized Agriculture Advisory System

Reality, Potential and Technology Challenges

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***Abstract*—The Indo-UK Advanced Technology Centre of Excellence in Next Generation Networks, Systems and Services (IUATC) is trying to address the future challenges identified by the UK Government under the Digital Economy Theme and the Department of Science and Technology in India. One such area in rural India where Information and Communication Technologies (ICT) networks can have a major impact is Agriculture. This paper presents a new approach to building an Agricultural Advisory System aimed at bridging the information gaps that exist between farmers and extension workers and agricultural scientists in a country like India. It demonstrates the power of two-way mobile phones today, which when combined with innovative methods could provide services to farmers that could not even be envisaged till yesterday. The customized and personalized advisory becomes especially important in the Indian context, where 52% of the population depends on agriculture but generates merely 13.9% of its Gross Domestic Product (GDP). With fragmented landholdings, the number of independent farmers has risen to 88 million with near-stagnant productivity. Growth-acceleration is possible only with customized advisory. India currently has a 900 million strong mobile phone subscriber base largely operating over voice oriented 2G GSM (Global System for Mobile Communications) and GPRS (General Packet Radio Service) networks. With ever increasing rural mobile penetration, personalized agricultural advisory is a distinct possibility. The paper presents an innovative technology development effort, analyses the technological challenges faced as well as discusses the feedback obtained from early field-implementation and focuses on what needs to be done in future to scale such systems.**

***Index Terms*—Mobile telephony applications, Agriculture Advisory System, Call Centre, Dashboard for farmers, Interactive Voice Response System**

I. Introduction

The contribution of agriculture to the overall Gross Domestic Product (GDP) of India has been falling rapidly and has gone down from 30 percent in 1990-91 to a mere 13.9 per cent in 2012 [1]. Even though the shift away from agriculture is a trend that is to be expected as a nation develops, the sector still remains the backbone of our country as it employs 52% of its workforce. Limited land and water availability (made worse by degradation of natural resources), fragmentation of land into small holdings, changes in demand and consumption patterns, climate changes, new pest and disease outbreaks, liberalization of trade as well as a move towards high-value agriculture are some of the challenges faced by Indian farmers, especially those with smaller landholdings [2]. The recent increase in global food prices should have provided these farmers an opportunity to increase their profitability, but lack of information at multiple levels prevented many from realizing its benefits. Information gaps exist in terms of what and where to buy much-needed inputs, how does one overcome stunted growth and disease outbreak, when and where to sell the produce as well as how and where to get information about financial services, transport and local weather. There is a strong need today to align the needs of farmers, their existing experience and knowledge base with modern agricultural trends and practices, by personalizing the information that is being delivered to them and making it interactive as far as possible. Today's agricultural extension service fails to do so. There are around 88 million farmers in India, with 98.5 million holdings (operating an average area of 1.1 hectare) [3] speaking some 20 different languages and many more dialects, dispersed geographically in 630,000 villages [4]. An interactive discussion with each farmer appears to be an unsolvable problem.

However a look at modern industries that have large number of dispersed customers shows us how. They have evolved methods of servicing each customer individually, providing highly customized service. Over the last few decades, call-centers with sophisticated technologies have become a backbone for such a service. Industry has learned to record the profile of each customer on a web-page, containing not only information about what and when the product was purchased, but also all the difficulties that the customer faced with the product in the past as a service history. Coupled with some FAQ available in a separate window, a relatively untrained (and therefore low-cost) call-center operator is able to provide satisfactory service; and when needed the operator can conference-in a more experienced and knowledgeable person to deal with queries. It is now understood that using a similar approach, Information and Communication Technology (ICT) could play a significant role in overcoming the current shortcomings in Indian Agricultural Advisory Systems.

The first question is whether ICT is accessible by the farmers. In 1994, India had less than ten million phones and was adding less than a million phones a year. Most phones were in urban areas and most villages did not even have a single phone. The primary bottleneck was the cost associated with local loop [5] [6]. India's income level was very low and most people just could not afford to spend enough to make the telephone operator break-even. Wireless telephony came as a boon. It replaced the wired local loop and, driven by Moore's Law as well as better and better signal processing, the costs of telephony were brought down significantly. Further, Indian telecom operators innovated [7] to reduce the operation costs and as a result the telecom tariff fell below 0.8 cents (Euro) per minute. At the same time, large numbers and some innovation brought down cell phone costs to as low as Euro 15. India quickly grew to 900 million phones [8] largely operating over voice oriented 2G GSM (Global System for Mobile Communications) and GPRS (General Packet Radio Service) networks. The villages were now connected over these networks offering robust voice connectivity and most farmers could afford a cell phone. While data-connectivity may be limited, these cell phones have a camera that supports sending a picture using MMS (Multimedia Messaging Service)besides offering voice telephony.

The other challenge is that most farmers are either illiterate or semi-literate. They are therefore not data-savvy and communication with them has to take place in the local language. While they are capable of taking and sending pictures, the rest of the communication has to be through voice. It is imperative therefore, that any agricultural advisory system takes these realities into account.

This paper presents a new approach to building such an Agricultural Advisory System aimed at bridging the information gaps that exist between farmers and, extension workers and agricultural scientists. It demonstrates the power of two-way mobile phones today, which when combined with innovative methods could provide services to farmers that could not even be envisaged till yesterday. In section 2, we present the technology development and implementation in the field. In section 3, we delve into the technological challenges faced while building such systems. The next section discusses the feedback received so far from the famers; we then conclude with a discussion on what needs to be done in future to scale such systems.

II. A NEW AGRICULTURE ADVISORY SYSTEM (AAS)

In this section, we present the architecture, the main technologies used and the innovative features of a new Agriculture Advisory System, built by RTBI [9] and IIT Madras [10].

A. Architecture of the Agriculture Advisory System

Fig. 1. Simplified diagram illustrating the architecture of the system

Fig.1 shows the architecture of the system. A simple Java-based mobile application was developed to enable field workers to collect data for each plot and register the farmer. Details such as farm location, plot size, soil type and soil testing results, history of crops grown, yield achieved, irrigation used, fertilizer and pesticide application were all collected and sent to a server using GPRS, to create an Agri-Advisory database and generate an individual farmer's web-page. In addition, farm plots with water bodies, drainage and irrigation channels have been tracked using GPS devices for the farmers registered with the system. This spatial data supplements the non-spatial data collected for every farmer.

B. Updating of information through Interactive Voice Response (IVR) module

Although some initial data is collected by the field staff visiting the farmer while making him/her aware of the service and training the farmer, the plot data would need updating every season. Specifically, inputs on the crop being grown, the kind and amounts of seeds, fertilizers and pesticides used would have to be updated for the operator to provide reliable advisory. Field staff visits every season for the purpose of updating data would be an expensive proposition. Instead, one could get the farmer to call the call-center operator to update the data; but even this would be expensive as operator time involved may be significant. Therefore a local-language, local-dialect automatic interactive speech recognition system that allows a farmer to regularly update his/her relevant crop information for the current crop being grown is built. The early trials have shown satisfactory performance.

C. Personalized Dashboard for every farmer and the Call-Center set-up

The personalized advisory is provided using a call-center set-up. The historical data for each farmer can be viewed through a web interface designed in PHP; details of every farmer are presented in a succinct and easy to read format to the call-center operator in the form of a personalized dashboard as shown in Fig. 2, 3 and 4.

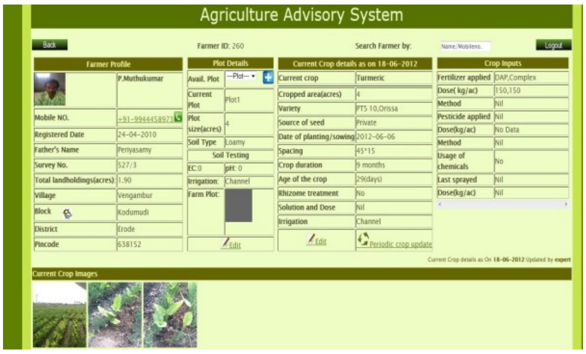

Fig. 2. Part of farmer's dashboard showing historical data and current crop details

Fig. 3. Part of farmer's dashboard showing historical data and pest & disease problems

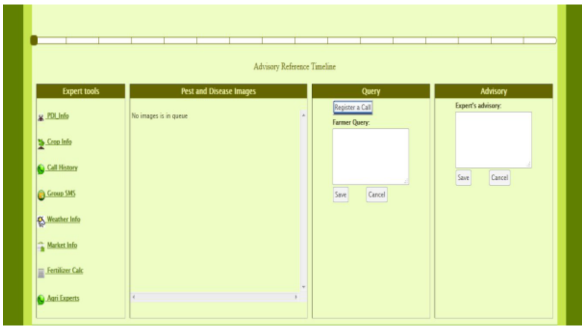

Fig. 4. Part of farmer's dashboard where an operator can avail of various tools, be alerted of pest/disease image uploads as well as record farmers query and advisory provided

When a farmer's call lands at the call-center, the CLI (Caller Line Identification) is used to pop-up the specific dashboard of the farmer on the screen with all the details related to the particular farmer, farm and crop being grown. The farmer can communicate his/her query to the call-center operator and the dashboard provides all the contextual information needed to quickly provide farm and crop-specific advisory. Further, the interaction between the farmer and the operator is recorded, forming a regularly updated advisory timeline which helps the operator / expert in tracking issues and concerns raised by farmer.

D. Pest and Disease Image Upload (PDIU) Feature

While contacting the call-center it was found that many farmers had queries regarding crop protection. They would try to explain the pest and disease problems to the operator through voice conversation, describing the infection. Often, the description was not good enough to come to the right conclusion resulting in an incorrect advisory. What was needed was an image of the affected crop, which would actually help the operator better understand the problem. The Pest and Disease Image Upload (PDIU) application is a simple Java based mobile application to upload images; a camera mobile phone enabled with GPRS or MMS is used by the farmer along with this application to quickly capture images of any infestation or potential problem areas of crops and upload it to the database. It is displayed on the operator's dashboard in real-time and helps in proactive advisory being given to the farmer.

E. Relay of Agricultural Advisory Messages

A parallel experiment, in partnership with the Agriculture Department, Government of Tamil Nadu, involves relay of agricultural advisories, using a PUSH based voice messaging system, to around 200,000 farmers in five delta districts of Tamil Nadu. The content of the messages varies widely; for example, it may include information about Government schemes provided to farmers from time to time, information on new crop production techniques, pest and disease management, etc. This kind of PUSH based voice messaging system provides information to farmers proactively and also ensures timeliness of the message.

The authors built the system to offer these advisories, customized to different groups of farmers and are driving the effort for the government. At the same time they are carrying out a study to gauge the value addition of such voice-based messages. A simple study involves a quick question or two asked to the farmer at the end of the voice message and the answers are tabulated. Another study involves a more rigorous follow-up, where the system calls a sample of farmers to address a well-structured feedback questionnaire, capturing the responses by means of an Automatic Speech Recognition system. The feedback obtained will be used to tailor the voice-messages and make them more relevant and better-targeted.

III. Technological Challenges

While the Agricultural Advisory system, presented in section 2, would be scalable as it does not require extension workers to travel to every village and meet every farmer on a regular basis, even then, the total cost of the service needs to be estimated. The farmers use their own phones to make calls and as the tariffs are very low this does not put much of a burden on them. The call center does have a huge data-base besides the display system along with the sophisticated headphones and speakers for each operator; but as the costs of the equipment gets shared and used over a long period of time, it does not add significantly to the costs of the advisory system. The main cost is that of manpower. Ideally one would have an experienced agricultural graduate as the operator handling the farmer's call. But their cost would be significant and could place a huge burden, especially when land is highly fragmented and farmers have small plots. Is it possible to use less-trained persons providing advisories at the call-center? This would be possible only if the information contained on the dashboard and in the FAQs is sufficient for the operator to handle the call in a satisfactory manner. Of course, such a call-center operator (advisor) would not be able to handle all the situations; the advisor should be capable of recognizing difficult situations quickly and conference-in an expert to further handle the call. The important question is what kind of information should the dashboard contain to be able to best aid the advisor in providing reliable, personalized advisory?

A. Human-Computer Interface Challenge

It is also important to address how best the information on the dashboard can be presented so that it is not cluttered and the operator can find what is needed easily? Ease of navigation on the dashboard will ensure that the operator can quickly open the right window to get the required information. The enormous amount of data and information contained in the FAQs has to be handled carefully. This has been the focus of the new discipline "Human Computer Interface (HCI)" but the key learnings need to be applied carefully to make sure that they are indeed aiding the operator in finding the required information and providing the right advisory.

B. Challenges involved in building appropriate Automatic Voice Response System

While a call-center set-up envisages that an operator answer each query of the farmer, one has to examine the possibility of an intelligent system answering some of the simple queries of the farmer without involving an operator. This is important as the number of farmers is large and only a system like this could meet the challenges of scalability. This would be possible if IVRS in local language and dialect becomes sufficiently mature to satisfactorily handle some of the queries. In the absence of quality engines for speech recognition in local language / dialects, this is possible only if a structured dialog is initiated by the system so that the answer to each question asked is limited and discrete; yet the dialog has to be friendly and flow in a manner that the farmer feels comfortable. It is a challenge to design a system that can respond to the farmer's call, initially through IVRS and then switch to an operator at first signs of farmer's discomfort.

C. Challenges in IVRS for crop-updates

As discussed in section II.B, data on crops at each farm needs to be updated every cropping-season. Again, due to the volume involved, this is best done through an IVRS with a structured dialog, without involving an operator. Designing such an IVRS, which captures the variation that each farm may have from season to season, is indeed challenging. The system has been developed and is currently ready to launch for trial.

D. Image-uploading Challenges

Farmers should be able to quickly upload images from their mobiles to the server at the call center for pest/disease identification and the same needs to be presented on the dashboard. An application which enables a farmer to do so has been designed and is now being used. The latest version has been designed in the local language and implementation of the same is expected to begin soon. A challenge is to make this application work on a large variety of phone-brands, which do not have any common OS, in use today. Further, enabling automatic/semi-automatic disease recognition in the system, based on the uploaded images, would certainly aid the operator in providing an advisory more quickly. Such a tool is currently under study [11]. Also, while the networks have been optimized for voice, GPRS does have bandwidth and delay challenges. For instance, at times, it might take a farmer 30 to 40 seconds to upload an image. Improvements in QoS (Quality of Service) over GPRS networks will lead to a more significant number of farmers adopting this technology.

E. Designing appropriate PUSH voice-messages

In the PUSH based voice messaging system, getting live feedback from farmers about usefulness and appropriateness of the message is critical. Having feedback integrated with every voice-message push and using IVRS/ASR to analyze the feedback is indeed a challenging task. An early version of the implementation is being field-tested today.

F. Business Model Challenge

Another challenge will be to understand the economics of each such intervention and figure out a business model for scaling. This would be a continuing task.

IV. Implementation Feedback

Both the Agricultural Advisory Systems, one using the call center approach and the other using the PUSH based voice messaging system has been implemented to serve farmers in a few districts of Tami Nadu, India.

The call-center approach was set up to serve about 1200 farmers in three districts. Half of these farmers started using it right in the beginning, but some dropped out after a few months. However 300 farmers have been using it regularly for about 12 months, with about 50 farmers calling-in every month. The early implementation had a few lacunae. The conferencing-in of the expert had not been enabled and the FAQ was weak. For over 50% of interactions, the call-center operator was not able to provide immediate advisory and had to contact the expert in an off-line communication. The solution was provided typically a day later and farmers were not happy with the delay. Also, the farmers found the image-uploading application to be a little complex and wanted a simpler version. Nevertheless, the farmers were very happy to receive personalized advisory based on the images they could send. Many were enthused enough to go ahead and purchase a new phone with better features, like GPRS and camera, for the sake of being able to use this application. The qualifications and training required for the operator to be able to efficiently manage the call-center, still needs to be understood. Further, the revenue model for this kind of approach has yet to be figured out.

The services using PUSH based voice messaging system have been implemented since August 2012 covering about 200,000 farmers in five districts of Tamil Nadu. About 1.8 million messages have been delivered so far. The crops covered were paddy, groundnut, sugarcane, sorghum, red gram, black gram, green gram and maize. The messages included information on system of rice intensification, certified paddy seeds, hybrid seed selection, seed treatment, sowing, fertilizer application (basal and top dressing), weedicide, pesticide, bio-pesticide, green manure, enriched farm yard manure, fungicide, foliar application and micronutrients. The messages also provided information on various Government schemes, such as availability of community nurseries and subsidies on farm-inputs. The early feedback is reasonably good. The quick-survey at the end of each message found that 91% of those who responded said that the messages were relevant and useful. The detailed questionnaire was administered to a sample of farmers. Nearly 80% said that the messages were of interest to them as many were hearing about the information (relayed via our system) for the first time and would take advantage of it. The end-of message questions will now be used to categorise farmers and make the messages more targeted.

V. Conclusion

While the discussions in the paper are based on work that has so far been carried out only in one state in India, Tamil Nadu, very recently the model was put in place for trial, through replication in another State in North India, Himachal Pradesh. It is interesting to note that while the crops that are in focus there are different and so is the terrain, the feedback obtained thus far is very encouraging. Discussions that have taken place with different Government officials and NGOs working with farmers indicate that the system could be evolved to be applicable to provide personalized advisories in most parts of India.

To conclude, mobile telephony reaching even remote parts of India does have a potential of transforming the under-developed regions of the nation. As the capacity and QoS in wireless networks, especially those offering data services, improves, there will be greater and more robust mobile connectivity in rural India. Personalized agricultural advisory leveraging this mobile connectivity may be the next most important thing for strengthening Indian agriculture and improving the productivity as well as livelihood for large sections of people in India.

Whether such a system would be useful in other countries in the world needs to be examined. It is highly likely that farmers of most developing nations would benefit from such an approach. Similarly, there are enough reasons to believe that with some modifications, the approach could be equally useful in providing customized service to farmers in more developed countries, for example that of Europe. One has to figure out the relative usefulness of using voice or data to provide the services in such a context; may be a combination would be the most effective approach. It is also possible that such services may be provided remotely from outside the country, similar to many other call-center services being provided today.

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References

[1] "State of Indian Agriculture," 2012. [Online]. Available: http://agricoop.nic.in/SIA111213312.pdf

[2] C. J. Glendenning, S. Babu and K. Asenso-Okyere, "Review of Agricultural Extension in India: Are Farmers' Information Needs Being Met?," December 2010. [Online]. Available: http://www.ifpri.org/sites/default/files/publications/ifpridp01048.pdf

[3] "National Sample Survey Office (NSSO)," [Online]. Available: http://mospi.nic.in/Mospi_New/Site/inner.aspx?status=4&menu_id=54

[4] "Census of India," [Online]. Available: http://censusindia.gov.in/Census_Data_2001/Census_data_finder/A_Series/Number_of_Village.htm

[5] A. Jhunjhunwala and B. Ramamurthi, "Wireless in Local Loop: Some Key Issues," *Journal of IETE,* vol. 12, no. 5 & 6, pp. 309-314, September-December, 1995.

[6] A. Jhunjhunwala, D. Jalihal and K. Giridhar, "Wireless in Local Loop, Some fundamentals," *Journal of IETE,* vol. 46, no. 6, November-December, 2000.

[7] A. Jhunjhunwala, B. Ramamurthi and T. Gonsalves, "The role of technology in telecom explansion in India," *Communications Magazine, IEEE,* vol. 36, no. 11, pp. 88-94, 1998.

[8] "Telecom Regulatory Authority of India (TRAI): Annual Report 2011-2012," [Online]. Available: http://www.trai.gov.in/WriteReadData/Miscelleneus/Document/201301150318386780062Annual%20Report%20English%202012.pdf

[9] IITM's Rural Technology and Business Incubator (RTBI), Chennai, India, [Online]. Available: http://www.rtbi.in

[10] Indian Institute of Technology Madras (IITM), Chennai, India, [Online]. Available: http://www.iitm.ac.in

[11] S. Hannuna, N. Ananatrasirichai, S. Subramanian, S. Prashant, A. Jhunjhunwala and N. Canagarajah, "Agriculture Disease Mitigation System," *ICTACT Special Issue on Next Generation Wireless Networks and Applications,* vol. 2, no. 2, pp. 363-369, 2011.