

Experts' Assignment Algorithm for Cloud-based Agro-advisory Service Information System (CASIS) using Weighted Sum Model: Piloting CASIS

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Abstract

A Cloud-based Agro-advisory Service Information System (CASIS) uses interactive operating mode where assignment of questions from farmers to experts is done manually. Questions as input to the system are received randomly in a day and experts are supposed to respond within a specified time. The system has 20 experts in its database who respond to farmers questions and it can receive more than 30 questions per day. If there is a significant delay in the responses to a question then the question is reassigned to another expert. Each expert behaves differently when responding to their assigned questions. In order to address the shortcomings, the experts' assignment algorithm was developed utilizing the respondents' response probabilities and time of responses. Assignment decision is based on using a model that trains 'CASIS' on the determination of best experts. CASIS training algorithm is developed to complement current weakness. The algorithm doesn't omit experts who respond late but complements them with active ones. The decision boundary is homogeneity and numerical so as to give a single output quickly. The input (x_1, x_2) and output (y) variables are numeric. The main concept is that the output is generated using linear combination or weighted sum model. The algorithm considers response time as best criteria to satisfy the farmers who send the questions. This algorithm provides a great chance of finding a quick answer within a short period of time. Automatic expert assignment is essential to achieve high adoption of the system that satisfies the on-time farmer advisories demand and promote efficiency as well as effective extension services for rural development.

Keywords: cloud-based, information system, extension, agro-advisory service, expert, CASIS

Background

The agricultural sector is one of the important drivers of many African countries' economies. The sector contributes nearly 30% of the continents Gross Domestic Product (GDP) and 70% of the continent's population depends on agriculture to sustain their life (WB, 2015).

According to World Bank, agriculture is an important asset for achieving the Millennium Development Goals (MDG) and a means to reduce poverty in sub-Saharan Africa (WB, 2011; WB, 2015). In Tanzania, more than 80% of population living in rural areas heavily depends on agricultural activities to earn their living (World Bank, 2011; WB, 2015). In 2003, agriculture accounted for half of the country's GDP, provided 51% of foreign exchange and employed 80% of the labour force. It accounts for half of the country's total GDP (World Bank, 2011; FAO/MAFAP, 2013; World Bank, 2015).

The agricultural sector in Tanzania is facing so many challenges that prevent its prosperity. Among the challenges that hinders the agricultural sector is ineffective agricultural extension services. Farmers have limited access appropriate information in space and time (Sanga *et al.*, 2014b). The Government of Tanzania has come up with different policies that address problems in agriculture sector. An example of such policy is the 'Kilimo Kwanza' Declaration (Agriculture First Declaration). 'Kilimo Kwanza' aimed at igniting the agriculture sector by emphasizing applying modern techniques of farming (URT, 2010). The Government has installed optical fiber across the country and it is now encouraging citizens to use different ICT- based services. Examples of ICT based services are mobile payment and agro-advisory services (i.e. Tigo Kilimo, Voda Club, Z- Kilimo, M-Pesa). The use of modern telecommunications services and ICT to support farmers has been studied broadly by various scholars (Gakuru *et al.*, 2009; Sanga *et al.*, 2013a; Sanga *et al.*, 2013b; Sanga *et al.*, 2014a; Sanga *et al.*, 2014b; Pongnumkul *et al.*, 2015). ICT has potential to facilitate quick access to information and relevant knowledge that may improve agricultural productivity, reduce poverty and ensure food security in developing countries (ITU, 2009). Use of mobile phones provides the next digital stage of providing extension education and service to the farmers remotely (Gakuru *et al.*, 2009; Sanga *et al.*, 2014a; Pongnumkul *et al.*, 2015).

Zerfu *et al.* (2011) reported that among the various problems cited for the poor performance and low productivity of African agriculture is the ineffectiveness of the agricultural advisory services. Neglect of agricultural extension systems in several African countries in the last two decades has resulted in declining agricultural productivity (World Bank, 2015). Despite the initiatives which have been made to understand the organizational and capacity issues that confront effective design and implementation of agricultural advisory services there is still a need to evaluated their impact in terms of efficiency and effectiveness (Sanga *et al.*, 2014b).

The adoption of new technologies in agriculture depends on two important factors, namely: user's own benefit analysis i.e. how the user perceives the technology and how much value does it have. The other important factor is the seriousness of the national programme or on the national legislation e.g. incentive to adopt it or punitive actions to ignore it (Hall & Khan, 2003). Most farmers in Kilosa district, in Tanzania perceive Cloud-based Agro-advisory Service Information System (CASIS) as an alternative advisory agent that provides useful agricultural information. In order to complement the conventional agricultural extension services in Kilosa District, SUA through a project under EPINAV (Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains) embarked on improving coverage of extension services through the use of mobile based CASIS. CASIS utilize the strength of ICT to deliver advisory information and knowledge to the farmers. CASIS consist of web-based agricultural knowledge and information system (WAKI) and mobile- based agricultural knowledge and information system (MAKI). The first version of CASIS required the farmers to pay for all the SMS that they sent to the system and the system had very few participants. The second version of CASIS allows utilizing the mobile bundles that the farmers use to send free SMS for agro-advisory service. This version is very attractive and

thus, it is used by many farmers in Kilosa District and some Districts of other regions in Tanzania.

The system also keeps record of all questions and their answers. Mobile based AAIS is the SMS based version of the web based CASIS. The farmers and extension agents can communicate without knowing each other. The farmer can send SMS using a specific dedicated number. After that, the control unit assigns a specific expert to answer the question. The expert will be notified by the system and respond by answering. Just after submitting the answer, automatically it is sent to the farmer. The farmer will see the answer using different means such as e-mail, web and mobile phones. The controller can also view and see the questions and corresponding answers and know who has answered the farmer.

Experiences and Challenges of CASIS

Weighted sum model algorithm

Automatic assignments of questions require that the system calculates the numbers of questions to be answered and the number of available experts to answer. It calculates using the WSM. This involves modeling the expert's response time and number of questions he/she has provided to the system. The request and response time is very important when responding to farmers questions. When the answer takes a lot of time then farmers tend to complain. This is always solved if the question is assigned to another expert who is going to respond very fast. The period under which the question has not been answered is called 'lapsing time'. The time at which the farmer's question is received to the system is called 'question time' while the time at which the farmer gets answer is called 'response time'. It could be noted that 'lapsing time' is the difference between the 'question time' and 'response time'. There is a delay when packets containing the answer move from the expert to the farmer. For modern technologies, this could be estimated to negligible.

It should be noted that the 'lapsing time' should be very small to account for best performance of advisory system. When it is increasing then the system acceptability is at stake. The greater the 'lapsing time' the less the system is going to be accepted by the farmers and other agricultural stakeholders.

The decision boundary (lapsing time) is homogeneity and numerical so as to give a single output quickly. The input (x_1, x_2) and output (y) variables are numeric. The main concept is that the output is generated using linear combination or WSM using the given set of inputs $y = p_1x_1 + p_2x_2$ where p_1 and p_2 are cumulative weighted probability of responding to questions. Probability adjustable as the expert answers the questions per week or per weekend. p is calculated using number of answers received against number of questions assigned. The algorithm considers response time as best criteria to satisfy the farmers who send the questions. x_1 (on workdays) and x_2 (on weekends) are determined using cumulative average answer wait minutes where scale is 1 to 40 where 1 represent 40 minutes and 40 represent 1 minute wait. p_1 represents probability of questions answered within 40 minutes wait time for a period of last 5 workdays. p_2 represents probability of questions answered within 40 minutes wait time for a period of last 2 weekends. Most experts don't respond to questions in weekends but this algorithm counts the points of weekend too when determining the best ones. In weekend days, the decision boundary can only be determined using $y = p_2x_2$ where p_1x_1 is considered as null decision variable when $y = p_1x_1 + p_2x_2$ can't give final decision. Table 1 shows the simulated data from the CASIS for six experts.

Table 1: The CASIS simulated data using WSM

The simulated data provides demonstrative example of the WSM. The best performer in this case study is expert F. He has accumulated a 35.66 WSM while the worst performer is expert B with 15.87 WSM. In order to achieve the maximum of 80 WSM, the experts will be required to provide answers within the shortest period of time (less than 1 minute) and answer all the questions that were assigned to them. This is quite challenging to our experts in Kilosa since they are providing free advisory service without any incentives.

WSM provides a fast decision output that could be fed to the system. It is likely that the WSM provide the same output every time. The random selection among the best performers is necessary. Also, random selection can be used to increase the total points of the weaker respondents. It is unlikely that the decision will be biased to the best performers. This means the system will try to lower the loads of the best performers by involving other individuals who may provide answers too. The lowest performer will be changing regularly, thus the system involves everyone in the group of those offering advisory so that each can get WSM points to be involved more in future.

The model was provided with data from the database where the live questions are to be fed to the model for decisions. The algorithm fetches the information from the database of our AAIS and determines the ‘lapsing time’ for each expert and then calculates the output.

This weighted model has provided an alternative to human being manual way of assigning questions and creates a room where biasness is avoided to increase efficiency of the system. The behavior of the extension officers toward answering advisory service through their mobile phones has dramatically changed and some have not changed (i.e. constant behavior). This algorithm is expected to provide best solutions to farmers without being concerned with the experts who provides answers.

Results and Discussion

The number of answered questions increases the points or credits to the best performers but it can be relying more on ‘lapsing time’. ‘Lapsing time’ of many questions is the average of ‘lapsing time’ of the week or month. Using week ‘lapsing time’ provides new data of the best performers. It means that the best performers of the current week can change dramatically. The worst performer could be incorporated to the new week. This looks like a moving average but with restrictions of the number of data. There is no specific week where the system can determine the best performer but it is the daily process where best performers are calculated.

Referring to Table 1, the expert who seems to be very fast in answering has not reached 40 WSM which is half of the maximum required. This shows that the algorithm was well simulated. In real sense, the extension agents in the database have not been answering questions within the 40 minutes of the assignment or lapsing time. In the database only 11%

of the questions were answered in period of 40 minutes. This is due to manual reassignment of the question which is difficult and the experts are not well motivated to provide fast response. In this model, the x1 or x2 can be adjusted to 50 or 60 minutes depending on satisfaction of the farmers.

Conclusion

This algorithm has provided the best solution to the manual assignment. The weakest point of the algorithm is that it can be biased to some individuals especially when the ‘lapsing time’ of the worst performers is very large. In order to get faster response then the efficiency of the algorithm is likely to avoid underperforming individuals. It is quite acceptable if the system performs wonderful automated assignment without giving burden to few best performers. The best performers should be compensated to their salaries so as to increase the morale to work hard. It is recommended that in future, we need to do a survey to farmers to ask them on the appropriate value of x (lapsing period) that they can wait for answer and then readjust the algorithm coefficient (x1 and x2) accordingly.

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Biography

Kadeghe Fue received his M.Sc degree from the University of Florida, USA in the summer of 2014. He studied precision agriculture, information systems and automation. He holds B.Sc(Hons) in computer engineering and information technology from the University of Dar es Salaam, Tanzania. He joined Sokoine University of Agriculture in October, 2011 as the member of academic staff. Kadeghe holds several awards received since 2004. Recently, He received the Pan African Conference on Science, Computing and Telecommunications (PACT) 2014 best student paper award in Arusha, Tanzania. Also, he received Borlaug LEAP fellowship award in the fall 2013. He is a graduate engineer member of the Institution of Engineers Tanzania since 2011 and American Society of Agricultural and Biological Engineers since 2013. He has specialized in applications of computers and electronics in Agriculture especially in area of Precision agriculture, e-agriculture and Software systems engineering. He has published several scientific papers in ICT for Development and applications of electronics

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