International Journal of Advanced Science and Technology
Vol.59, (2013), pp.41-52
http://dx.doi.org/10.14257/ijast.2013.59.04

AgroMobile: A Cloud-Based Framework for Agriculturists on Mobile Platform

Shitala Prasad[1], Sateesh K. Peddoju[2] and Debashis Ghosh[3]

[1, 2]*Department of Computer Science and Engineering,*
[3]*Department of Electronics and Communication Engineering,*
IIT Roorkee, 247667, India
{shitala, sateesh}@ieee.org, ghoshfec@iitr.ac.in

Abstract

Today, use of mobile devices is very common by everyone, including the farmers. Introduction of Information and Communication Technologies (ICT) has seen a keen role in daily life of farmers. Earlier, farmers used to depend on clouds for rains were looking into the Cloud Computing (CC) for their solutions towards cultivation of better crops in modern agricultural world. The conventional methods used by the farmers, particularly in India, are very slow and unreliable. The crops are damaged in field itself due to disease attacks and lack of information resources. This loss grows more than 40% *in total annually. This paper proposes various ways in which a farmer can utilize MCC on their handsets using application called AgroMobile, to assist them for relatively better cultivation and marketing. The main attention of this work is focused on crop image analysis. Image processing techniques requires large amount of computation power and memory to process for which a mobile devices fails. Hence, this framework uses MCC, which in effect, these authors believe that, puts cloud into a farmer's pocket. The experimental setup uses tools like OpenNebula 2.0, and MATLAB 2012b. In this research an Android based mobile devices are used for testing but this is not the only device.*

Keywords: *Mobile Computing; Cloud Computing; Mobile Cloud Computing (MCC); AgroMobile; Image Processing*

1. Introduction

Computer vision, machine learning, mobile and cloud computing are the immerging techniques and are used in almost all fields of research as well as in our day-to-day activities such as medical imaging and agriculture. India being an agriculture based developing country has more than 70% of its population depending on agriculture and farming [1, 2]. The growth in the agriculture production directly increases the Indian Economy and vice-versa is also true. An expert system in the field of agriculture can be the best option to expand countries agriculture production. But the life style of Indian farmers and farming is varying rapidly due to increase in non-agricultural opportunities. The technological innovations in agriculture are not reaching to the farmer's, either because most of them are illiterates or due to unawareness. Hence, most of the farmers are failing to acquire the possible production rate. The loss growing more than 40% in worldwide which includes more than 19.1% of loss due to diseases caused, bacteria, virus and fungi, 10.2% due to insects attack and 12.2% due to weeds [3].

Information Communication Technology (ICT) plays a vital role to overcome such short comings. Marty Lariviere [4] is using cloud for agriculture in Japan to improve the

ISSN: 2005-4238 IJAST

knowledge of farmers of various types of the country. Ferzli *et al.*, [5], stated that mobile computing can be used for education purposes too, which are based on offline computation. This paper, opens a new dimension in the field of agriculture and irrigation with the help of new technologies, such as image processing, visualization and mobile cloud computing which really contributes in national economy and leads the developing countries to a developed ones. The mobile client(s) and the cloud are transparent, *i.e.*, cloud computing is transparent to end user(s) and overcomes all limitations of mobile devices and makes it more reliable, usable and extensible in large scale.

The rest of the paper is followed as: Section 2 presents related mobile cloud computing work done. Section 3 discusses the proposed conceptual model and architecture in farmer's perspective and the next section explains the design and functionalities of the proposed model. In the fifth section a brief implementation and experimental result is shown and at the last the paper is concluded and throw lights on possible future works.

2. Mobile Cloud Computing

The term Mobile Cloud Computing (MCC) is basically a combination of two technologies: mobile computing (MC) and cloud computing (CC), in which a mobile client can use CC without any limitations of any type of fixed equipments. That is MCC is the availability of cloud services in a mobile ecosystem. Song and Su [6] describe a basic model of MCC identified with short comings and their possible solutions. In [7], Yuan discussed the usage of mobile computing to share resources and transport data among each other reducing the processing burden on the mobile devices, the clients. But there are several challenges in implementing cloud services with mobile environment and deploying it on the mobile devices [6-8]. The main problem is that, MCC technology depends on the continuous network connection, failing which fails the system completely, the client is blank. Other challenges include network latency, the limited bandwidth of a mobile network, access schemes in mobile environment, elastic applications, and security and privacy schemes [8]. In MCC the mobile screen is limited and there by the cloud requirement is varied by context.

The importance of MCC for education is being pointed out since a decade and focused on teacher-student classroom interaction. In [9, 10], authors have used mobile computing techniques in the education system evolving tablet PCs. Mobile devices are increasing the processing power with increase in clock frequencies up to one GHz [11], but still fails to serve a real-time services such as image analysis, farmer's education, awareness, government polices and applications to improve the learning process which involves high computational costs and requires a dedicated high-speed processors like GPUs. To such problems mobile cloud can be the best solution. The characteristics of mobile cloud computing is "anywhere anytime secure data access" where 'anywhere anytime' is derived from mobile and from wireless 'without wire' is inferred. Three main characters are: (1) privacy, (2) data ownership, and (3) security in respect with multi users and anywhere anytime [6].

There are many conceptual models for MCC architectures containing an agent-client scheme [12, 13], and a collaborated scheme [14, 15] but this paper proposes a very simple model for agriculture. The next section covers the proposal of how a mobile cloud computing is useful to the farmers in their day-to-day agricultural needs.

3. Conceptual Architecture

In this section, we present a concept model of MCC technology for farmer's daily need on a simple handheld device called '*AgroCloud'*. In Figure 1 below, an AgroMobile server is established that includes Application Service Providers (ASP) providing on-demand software,

called software as a service (SaaS), over the network architecture to the customer(s). Here, customers are the farmers how don't have technical knowledge about the software to use and maintain. The developer is connected to the ASP and the end users are connected to AgroMobile infrastructure providing application services. The applications involved are designed such that it is simple and easy in use, for literates as well as for illiterates, both. The end users can be a smartphone, tablet, laptop, or phablet which supports the 2.5G, 3G or 4 G technologies, distributed all over.

The concept of mobile cloud is used in this project to solve various issues which simple mobile devices are unable to achieve. MCC allows the users device to maintain very small thin layer architecture only for few applications and to pushes all the computational processing workload(s) to the virtual machines on the cloud side.

1. MCC overcomes the limitations of mobile processing power and data storage, helps extending the battery life by moving the computations on cloud server.
2. Using cloud service MCC increases the security level of every mobile devices and increases mobility.

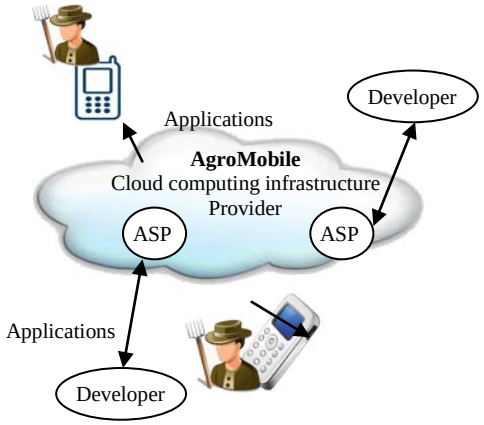


Figure 1. The Proposed AgroMobile System Model. Application Service Providers (ASP) and Mobile End User

The mobile cloud framework proposed here is focusing on the farmer's needs and requirements useful for their cultivation. Whatever query they have or they want to know from an expert can be answered on the spot simply using their handsets. More or less the image processing part is an important key in this architecture to process and analyze the field status just by clicking the leaf images. This model is not limited to farmers only but can also be used by the botanists too in their research to identify various species and diseases. However, this model can be rescaled for other applications too in future. In the next section, more detailed work is described.

4. Proposed Model and Design

The information required always has the power of improving the efficiency of agriculture in all aspects. IT has to play a big role in Indian agriculture to facilitate farmers in improving the productivity allover [1]. Technology can be used in two ways: (1) as a direct tool in agriculture production, such as satellite technologies, geographical information systems, agronomy and soil sciences, and (2) as an indirect tool for empowering farmers to take information and have discussions which positively improves the agricultural activities that

were traditionally conducted. At present, the Indian farmers as depending on the conventional source of input which are really slow and unreliable and non-periodic [1, 16]. The farmers basically needs some information such as weather forecast, government policies and applications, bank transaction information, chemical controls and pesticides awareness for proper monitoring and effective cultivation, discuss in more details in the next sub-section. Porcari [16], introduced the CC in agriculture which enabled inexpensive processing required to participate in agricultural research and [17] proposes a cloud based learning system.

Almost 4.6 billion mobile users are recorded in the year 2009 which is 370 times of year 1990 [8], and day-by-day the computation capacity of such mobile devices are going on increasing, such that today 1.8 GHz processors are available with mobile devices. Such high processing devices are becoming very common and cheaper in current market and are capable of providing cloud services that has 2.5G, 3G or 4G. In this proposed system, Mobile cloud computing in perspective of farmers provides Software as a Service (SaaS) and also Information as a Service (IaaS) used for education and awareness of agriculture and cultivation. These services are well customized, simple and flexible that anyone to handle and use.

4.1. Farmers Education and Awareness

Indian farmers are poor in educational background and thus mostly ignore the modern advancements in agriculture and thus the traditional methods are dominating over the modern technologies in this dynamic environment resulting bad production rate. This is due to illiterate or less educated farmers having low investment capacity working for the welfare of their people only. To increase the investment capital Indian government are planning and investing a huge amount but due to the lack of information farmers are unable to utilize them and they are off no use.

India does require education at all the levels of agriculture so that the Indian farmers and farming are equipped with these latest technologies and can handle the global threats. The traditional and the conventional way of educating farmers are through radio and television which is not customized according to the farmers need and thus they are of not much used. The query they have is unattended or if attended then its quit late resulting ultimate loss. And they are under pressure that they even need to commit suicide especially the states such as Andhra Pradesh and Maharashtra as they are unable to fulfill the bank loans. Though government is giving their full support but people of rural areas are not aware of. Education on private investment in agriculture such as Exim Bank Agro of India and National Bank for Agriculture and Rural Development (NABARD) [18] but not covered by majority of Indian farmers. There are many types of farmers in India such as illiterate and literate farmers, with small and large farms having different regions and types of farming like dry farming, humid farming, irrigation farming and plantation farming and to guide all of them is not possible by a conventional media or group discussions at local regional level.

4.1.1. System Functional Design:

To design a full-featured AgroMobile farmer's perspective with a real-time response, easy to use and flexible with storage interaction helps farmers to query their doubts and get related information on the spot without waiting for any expert to come and suggest. It provides:

1. Multi-functional software to serve farmers to get the detailed information about crops and their diseases and causes.
2. Interactive learning service to put there question and get reply spontaneously whatever wherever on time. And there is no limitation of language(s).

3. A multi-lingual services, that is AgroMobile is capable of translating all Indian languages to a standard one that is English and vice-versa.
4. All forms of learning such as audio and video lectures for illiterate farmers of India.
5. A dynamic storage service with a good GUI on mobile client that helps farmers and others to upload and download all the resources and the relevant data to & from the cloud server with nominal rate or freed.
6. It can act as a real-time question answering service too.

There is no limit for mobile cloud computing in farmer's education and making them aware of the facts and improve their production rate. In this fashion no need to have a ground level eye for the farmers and make easy government to monitor. What else AgroMobile can be used for?

4.2. Weather Forecasting

In India farmers rely on weather forecasts to decide as what work to do today and tomorrow. Whether to dry hey or keep it inside. The frost and freeze damages the crops in spring and thus what is the condition for next few days. Hence, AgroMobile provides SaaS to monitor the weather conditions without typing any location or position as it will be automatically located using the mobile device GPS system. And also farmers can query for the temperature and humidity required for the particular crop(s) as an Android application.

4.3. Crop Advice and Analysis

India has mainly two agricultural seasons in a year: the Kharif season or summer season and the Rabi seasons or winter season. Thus, a proper advice for the correct crop to plant is very much needed to fulfill the need of India. Farmers more than an age of fifty uses their own traditional way of cultivation and harvesting and may result good but the new farmers with young age group mess-up and results failure. Here, AgroMobile computing helps such farmers to look up the correct crop to plant after a particular crop. This IaaS also provides information for a single, double and multiple cropping and increase the knowledge of crop rotation and the mixed cropping. This all service is in real-time and on the users mobile device itself in a customized form.

After this IaaS, a SaaS for crop analysis is proposed. In this service, the crop images are sent to the server and asked to process and analyze it. The seasonal disease attacked in field can be known using Image Processing (IP) algorithms and some knowledge-based classifiers running on the server, by the virtual machine [19] allowing hardware and memory virtualization. The processing is done offline as to reduce the workload of mobile device. A low-level image processing operations can be performed on the mobile devices like color transformation, gamma correction, linear and non-linear filtering, simple noise reduction, image enhancement, and others. These operations are simple and requires less memory for execution and can run on mobile devices with low bit processor.

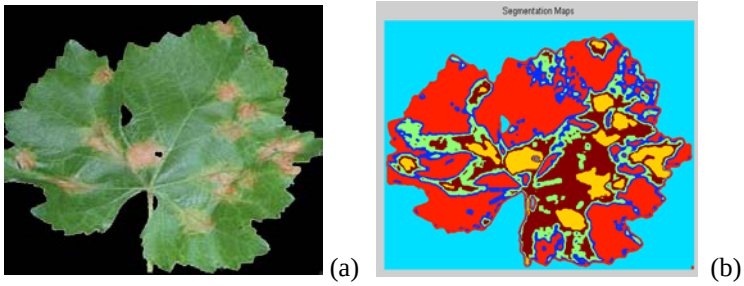
The intermediate-level and high-level image processing operations are segmentation [20], extraction edge, lines and contours, object recognition. In [21] plant species are identified using Curvelet transform, equation 1, and many other methods are running on the server. They all are computationally complex algorithms and executed on AgroMobile servers with a high computation and memory power. There it introduces a distributed computing concept helping Indian farmers at every grass root levels.

$$c^D(j,l,k) = \sum_{0 \le t_1,t_2 < n} f[t_1,t_2]\, \varphi^D_{j,l,k}[t_1,t_2] \qquad (1)$$

where, D means digital and $\varphi_{j,l,k}^{D}$is a digital Curvelet waveform, $f[t_1, t_2]$is input image and $cD(j,l,k)$ is the output set of Curvelet coefficients. $(t1\ t2)$ are the coordinates of the image and (j,l,k) are the various parameters such as angle, scale of a digital Curvelet transform.

It can also provide information according to the crop recognition result computed on the server, the suitable natural and chemical controls and their nearby centers where they can get, government as well as privet centers using a GPS (Global Positioning system).

Using image analysis for disease detection and identification [20], farmers can also know the status of their crops and perform the needful steps. A leaf disease segmentation snapshot is shown in Figure 2 executed on the server. This will improve the vegetation rate and help farmers to monitor their land more easy and more convenient way.



(a) (b)

Figure 2. Disease Segmentation (b) on Server Side using Block-based Unsupervised Color Image Segmentation [19] on Image Sent by the Mobile Client (a)

The functional services provided by the proposed AgroMobile computing are shown below in Figure 3. The only problem in AgroMobile is bandwidth for offloading the tasks. But the communication technologies today and in future are constantly increasing and a high bandwidth with constant connectivity with 3G and 4G technologies solves it.

The alternate way can be, if the mobile device losses the communication connection with the AgroMobile cloud server then the device itself must be capable to compute the remaining task using some caching concept, such as cloudlet.

White *et. al.*, [22], introduced a prototype for the botanist to identify the plant species automatically. In this prototype, a Tablet PC with Wi-Fi camera and Bluetooth GPS sensor is used to capture and analyze the images and provide the text information about the species. It is a CBIR based prototype for automated plant species identification. The systems proposed by [22-24] use shape information of the leaf captured and matches to their dataset stored in the Tablet PC and will fail to result for incomplete leaf data samples. But in the proposed system, it works very well for such samples too.

5. Simulations and Experimental Results

For the simulation, various tools have been used such as for Image Processing MATLAB 2008a is used and for implementing AgroMobile, OpenNebula 2.0 is used on server machine. OpenNebula, an open source cloud computing toolkit is used to manage heterogeneous distributed data center infrastructures used in this paper. It manages all virtual infrastructures of various data centers to build a private and a public cloud. It monitors and virtualizes all the services using multi-tier architecture having high security. On the other side that is on client machine, a simple application is designed to capture natural leaf image and push it automatically to the AgroMobile and wait for the results. The result is in two formats: firstly an image with the detailed information and secondly text information for the same is SMSed

(short message service). Sometime video information is also important and can be provided for few very common problems. After being processed the result is pushed back to the mobile client. The application designed for Android OS of version 2.3.5 and above with a processing speed of 860MHz and above.

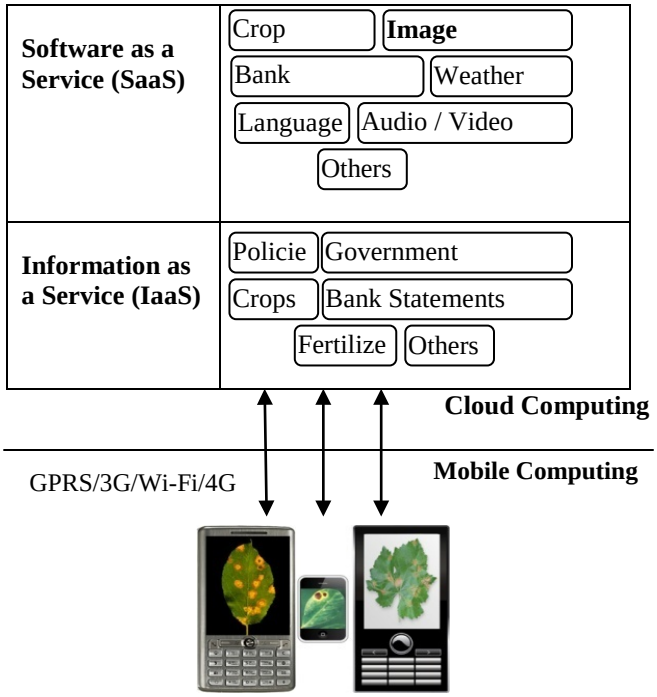


Figure 3. The Proposed Services of AgroMobile Computing

As this system is developed particularly for the Indian farmers, the application must be designed very simple and easy to learn and use is a challenge. For a farmer everything is hidden, *i.e.*, transparent and thinks as if his/her mobile is an expert botanist. The connectivity between mobile client and the cloud is via GPRS/3G/4G but for our experiment purpose Wi-Fi is used and thus this prototype model work only in the campus.

To reduce the workload the task is divided into two parts: the pre-processing and machine learning. In the per-processing algorithms are used are noise removal, normalization, image equalization, and few morphological operations performed on the mobile device itself, just on a button click. Within few seconds the result is revert back from AgroMobile to the mobile device after applying feature extraction, feature selection, and machine learning algorithms. For machine learning algorithm support vector machine (SVM) is used with Radial base function (RBF) kernel, equation (2), where (x, x') is the Euclidean distance of the support vector and the testing data point and R determines the area of influence over the feature space. RBF kernel adds bumps to the low dimension features to represent it in the high dimension feature space.

$$kr(x, x') = e^{-R||x-x'||^2} \quad for\ all\ R > 0 \qquad (2)$$

The results can be seen in Table 1 and Table 2, below. The dataset used are homemade. For plant leaf species identification 24 different plant samples are used, see Figure 4 and for disease detection only six classes are used, Figure 5.

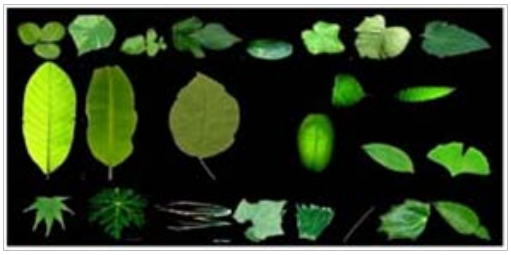


Figure 4. Plant Leaf Identification Samples

Table 1. Comparison and Accuracy Result for leaf Identification

Feature	Classifier	Validation Approach	Accuracy
Wavelet [25]	SVM (RBF)	---	95%
RSC [26]	Back-Propagation Neural Network	One-leave out cross validation	93.02%
RSC [26]	SVM (RBF)	One-leave out cross validation	97.25%
Curvelet [21]	SVM (RBF) *C*=100	One-leave out cross validation	Average: 96.02% (level 6)
Gabor Wavelet	SVM (RBF)	One-leave out cross validation	Average: **98.96%**

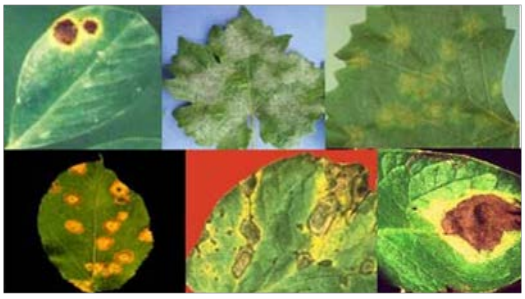


Figure 5. Plant Leaf Disease Identification Samples

6. Conclusion

In this paper, a new research activity in field of Mobile Cloud Computing (MCC) in farmer's perspective is explored which is termed as AgroMobile opening a new dimension to research. The proposed framework for farmers especially the Indian farmers to assist them in agricultural needs. We presented a new way of interaction to a botanical species recognition and disease detection using a simple mobile phone with camera–a Mobile Vision. AgroMobile is aimed to utilize all the advantages of cloud computing technologies on to a simple mobile device particularly the mobile phones, reducing the workload on the farmer's devices and running the complex algorithms like high-level image processing on the cloud server. The proposed system helps farmers in all manners, that is, in education, weather forecasting, crop analysis and understanding it more clearly. It provides the future information on the figure tips at any time anywhere to the farmer with the farmer.

Table 2. Comparison and Accuracy Result for Diseased Leaves Identification [20]. (Confusion Matrix)

Diseases	Wavelet (db4) Same Class (out of 10)	Gabor Wavelet Same Class (out of 10)	Gabor Wavelet One-Versus-all (out of all)
Tikka	10	10	0
Powdery Mildew	8	8	2
Downy Mildew	2	9	1
Late Blight	9	10	0
Early Blight	8	10	0
Rust	10	10	0

As a future work, we can improve the AgroMobile architecture by introducing many more algorithms for crop analysis and reduce the distance between the farmers and the government. Apply cloudlet concepts for remote locations. And use virtualization concept so that other that the Android OS other platforms can also use this application. The other alternative way is to increase the dataset for plant species and leaf diseased image. We can also think of other daily application to switch on MCC.

References

[1] S. C. Mittal, "Role of Information Technology in agriculture and its Scope in India", www.iffco.nic.in/applications/brihaspat.nsf/0/.../$FILE/it_fai.pdf, **(2012)**.
[2] P. Sharma, "Necessity of education and awareness in farmers: the basis of agricultural progress in developing and underdeveloped nations", Agriculture and Biology Journal of North America, **(2010)**, pp. 387-390.
[3] G. N. Agrios, "Plant Pathology", Fifth Edition, University of Florida, **(2005)**.
[4] M. Lariviere, "Kaizen and Cloud Computing for Agriculture", **(2011)** January 20, http://operationsroom.wordpress.com/ 2011/01/20/ kaizen-and-cloud-computing-for-agriculture/
[5] R. Ferzli and I. Khalife, "Mobile Cloud Computing Education Tool for Image/Video Processing Algorithms", Proceeding of IEEE Digital Signal Processing Workshop and IEEE Signal Processing Education Workshop (DSP/SPE), **(2011)**, pp. 529-533.
[6] W. Song and X. Su, "Review of Mobile Cloud Computing", Proceeding of 3rd International Conference on Communication Software and Networks (ICCSN), **(2011)**, pp. 1-4.
[7] M. Yuan, "Mobile Computing", Harbin: Harbin Industrialization University, **(2008)**, pp. 2-10.
[8] L. Guan, K. Xu, S. Meina and S. Junde, "A Survey of Research on Mobile Cloud Computing", Proceeding of 10th International Conference on Computer and Information Science (ICIS), IEEE/ACIS, **(2011)**, pp. 387-392.
[9] G. Roessling, H. Baer, C. Trompler and C. M. Choi, "Mobile computing in education", ITiCSE, **(2003)**.
[10] S. Prasad, A. Prakash, S. K. Peddoju and D. Ghosh, "Control of computer process using image processing and computer vision for low-processing devices", Proceeding of ICACCI'12, **(2012)**, pp. 1169-1174.
[11] N. Balasubramanian, A. Balasubramanian and A. Venkataramani, "Energy consumption in mobile phones: a measurement study and implications for network applications", Proceeding of 9th ACM SIGCOMM Conference on Internet measurement Conference (IMC'09), **(2009)**, pp. 280-293.
[12] X. Zhang, J. Schiffman, S. Gibbs, A. Kunjithapatham, and S. Jeong, "Securing elastic applications on mobile devices for cloud computing", Proceedings of workshop on Cloud Computing Security, Chicago, Illinois, USA, ACM, **(2009)**, pp. 127-134.
[13] M. Satyanarayanan, P. Bahl, R. Caceres and N. Davies, "The Case for VM-Based Cloudlets in Mobile Computing", Journal of Pervasive Computing, IEEE, vol. 8, no. 4, **(2009)**, pp. 14-23.
[14] M. Black and W. Edgar, "Exploring mobile devices as Grid resources: Using an x86 virtual machine to run BOINC on an iPhone", Proceeding of 10th IEEE/ACM International Conference on Grid Computing, **(2009)**, pp. 9-16.
[15] E. E. Marinelli, "Hyrax: Cloud Computing on Mobile Devices using MapReduce", Ph.D. Thesis, School of Computer Science, Carnegie Mellon University, **(2009)**.
[16] E. M. Porcari, "Connecting People, Technology and Knowledge for Agricultural Innovation: Ubiquitous networks and cloud computing", **(2009)** May 10, http://ictkm.cgiar.org/other_activities/2252_Porcari_ Ubiquitous_ networks_ and_cloud_computing__2_.pdf.

[17] S. Chen, M. Lin and H. Zhang, "Research of mobile learning system based on cloud computing", Proceeding of International Conference on e-Education, Entertainment and e-Management (ICEEE), **(2011)**, pp. 121-123.
[18] "Scope of Agriculture Education in India". http://www.indiaeducation.net/Agriculture/Scope.aspx.
[19] X. Chen, "Smartphone Virtualization: Status and Challenges", Proceeding of International Conference on Electronics, Communications and Control (ICECC), **(2011)**, pp. 2834-2839.
[20] S. Prasad, P. Kumar and A. Jain, "Detection of Disease Using Block-Based Unsupervised Natural Plant Leaf Color Image Segmentation", Swarm, Evolutionary, and Memetic Computing, LNCS, Springer-Verlag Berlin Heidelberg, vol. 7076/2011, **(2011)**, pp. 399-406.
[21] S. Prasad, P. Kumar and R. C. Tripathi, "Plant leaf species Identification using Curvelet Transform", Proceeding of 2nd IEEE International Conference on Computer and Communication Technology (ICCCT'11), **(2011)**, pp. 646-652.
[22] S. White, D. Marino and S. Feiner, "Designing a Mobile User Interface for Automated Species Identification", Proceeding of ACM CHI, **(2007)**, pp. 291-295.
[23] F. Mokhtarian and S. Abbasi, "Matching shapes with self-intersection: application to leaf classification", IEEE Transactions on Image Processing, vol. 13, **(2004)**, pp. 653-661.
[24] H. Goau, P. Bonnet, A. Joly, N. Boujemaa, D. Barthelemy, J. F. Molino, P. Birnbaum, E. Mouysset and M. Picard, The clef 2011 plant images classication task, **(2011)**.
[25] J. Liu, S. Zhang and S. Deng, "A Method of Plant Classification Based on Wavelet Transforms and Support Vector Machines", Proceeding of Springer ICIC 2009, LNCS 5754, Springer Berlin / Heidelberg, **(2009)**, pp. 253-260.
[26] S. Prasad, K. M. Kudiri and R. C. Tripathi, "Relative sub-image based features for leaf recognition using support vector machine", Proceedings of ACM International Conference on Communication, Computing & Security (ICCCS '11), **(2011)**, pp. 343-346.

Authors

ShitalaPrasad, received the B.Tech. degree in Computer Science from the College of Engineering and Technology IILM, Noida, India, in 2009. Soon after his graduation, he joined M.Tech. in Information Technology from Indian Institute of Information Technology Allahabad, India in year 2009. He did his specialization in Human Computer Interaction (HCI). He received a gold medal in BTech. in 2009. He is currently pursuing Ph.D. degree from the Indian Institute of Technology Roorkee, India. His major research areas are Image Processing, Face Recognition, Gesture Recognition, Virtual Reality and OCR. He also works on Image Processing in Mobile Computing and Cloud Computing.

Sateesh K Peddoju, received the M.Sc. degree in Physics and Specialization in Electronics from Kakatiya University, Warangal, India, in 1995, and the M.Tech. and Ph.D degrees in Computer Science and Engineering from the Osmania University, Hyderabad, India, in 2003 and 2010, respectively. From 1997-2010, he joined various different engineering colleges at different positions. He is currently an Assistant Professor with the Department of Computer Science and Engineering, Indian Institute of Technology Roorkee, India. He is currently holding the position of joint secretary of computer society, IEEE India council. His teaching and research interests include Grid Computing, Cloud Computing, Mobile Communications, Mobile Ad-hoc Networks and Mobile Cloud Computing. He has many national and international research publications.

Debashis Ghosh, received the B.E. degree in Electronics & Communication Engineering from M.R. Engineering College, Jaipur, India, in 1993, and the M.S. and Ph.D degrees in Electrical Communication Engineering from the Indian Institute of Science, Bangalore, India, in 1996 and 2000, respectively. From April 1999 to November 1999, he was a DAAD Research Fellow at the University of Kaiserslautern, Germany. In November 1999, he joined the Indian Institute of Technology Guwahati, India, as an Assistant Professor of Electronics and Communication Engineering. He spent the 2003-2004 academic year as a visiting faculty in the Department of Electrical & Computer Engineering, National University of Singapore. Between 2006 and 2008, he was a Senior Lecturer with the Faculty of Engineering and Technology, Multimedia University, Malaysia. He is currently an Associate Professor with the Department of Electronics & Communication Engineering, Indian Institute of Technology Roorkee, India. His teaching and research interests include image/video processing, computer vision and pattern recognition. He has many national and international research publications and transactions.