Portable Embedded Decision Support System

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Abstract. This paper describes a work on a project the goal of which is to develop a multi-purpose embedded system which will provide its users with advices in the desired field from user provided information and externally gathered data. The solution is based on an embedded system built on a custom Windows CE platform and extended with various pluggable sensors or modules to gather relevant data from the external environment. These input values together with the user provided information will be processed by a knowledge base system. Subsequently, the acquired results will be presented through a graphical user interface. The desired field, in our case agriculture, is theoretically unlimited and depends only on the knowledge base and modules used in the embedded system. Our device will provide advices on what kind of vegetables or fruits are suited to be grown at a given place and time.

1 Introduction

Our research is aimed on the field of agriculture. Agriculture is arguably one of the most important industries needed to sustain the basic needs of growing population. The increasing demand of large amount of quality food is forcing the scientists to find new ways to increase the efficiency of cultivation. Modern technology offers multiple techniques to achieve the needed solution.

By default, the crops are grown on cultural or historical basis. On one place the same kind of fruits or vegetables are grown for centuries, often not taking environmental

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conditions and other dependencies such as people's requirements and demands into account. In our work we focus on problem of fitting the right fruits and vegetables to the suitable time, place and environment.

In agriculture, operational research methods are used in order to find optimal characteristics of the objects investigated, considering time, resources, technological and other restrictions. The methods of mathematical programming method are successfully applied to improve agricultural system planning [2], [7].

These problems can be solved by implementing a decision support system (DSS) which considers input factors and expert knowledge to simulate the reasoning process of an expert in this area to come to a decision. Decision making process can be based on various factors and variables. System becomes much more complicated, the more variables it considers. Possible solution of dealing with complex variables and rules is to use a knowledge base system (also known as expert system).

The system is supposed to be used by a farmer, thus one of the main requirements of the system is simplified operability and usability in the real world conditions. In order to allow the user of the system to use it comfortably we decided to build it on a portable platform, in our case an embedded system based on Windows CE operating system. This solution represents a modern approach to leverage embedded systems.

DSS provides a farmer or consultant with a possibility to choose proper variants of farm management by evaluating dynamically changing weather conditions, new technologies, changes in the fields and general agricultural policy. DSS may consist of many subsystems, each of them has its specific task. Various expert systems are widely used in agriculture; however, they are often developed for autonomous computers and aimed at solving highly specific agricultural problems. DSS must satisfy users' requirements as much as possible; the data it contains must be easily updated. Convenient on-line systems serve the purpose [4], [5].

The result of our research will be a comprehensive knowledge based system integrated into a multi-purpose embedded system extended with various sensor modules providing input values from the environment.

2 General Overview and Purpose of the System

The overall purpose of the system is providing suggestions, coming from user input and externally gathered data. These input values are processed by the knowledge base system. Subsequently, the acquired results are presented through the graphical user interface. The desired field (agriculture in our case) is theoretically unlimited and depends only on the knowledge base and modules used in the embedded system. The knowledge base contains information that will in combination with the input values lead to a decision.

The basic principle is to gather environmental and user data and suggest the feasible vegetable or fruit to be grown at the given place and time. Examples of data are temperature, humidity, soil acidity, localization data to detect climate zone, allergic reactions, preferred fruits, etc. This information can help the knowledge base system to

make the most relevant decision.

3 Knowledge Base Systems

Knowledge base systems belong to a field of artificial intelligence, which tries to substitute human being in various difficult deciding and planning activities. However, main point is impersonating of human thinking, because people are able to make a decision based on incomplete information.

Knowledge base system is a computer program that is programmed to deal with desired problems with use of knowledge from a given domain. In principle, it is about utilization of knowledge of experts in the given field, for individuals who do not have this knowledge and the expert system simulates behavior of the expert.

There are two important parts of expert system. The first is knowledge base, in which knowledge of the expert is stored in form of facts and rules that consist of IF and THEN definitions. If condition is met, definition of THEN clause will be executed. The other part is inference mechanism that uses knowledge base in reasoning together with information from user. Expert systems mostly work as a dialogue between user and system where system asks questions. The answers are represented as temporary facts in knowledge base [3]. This interaction is displayed on the Figure no. 1.

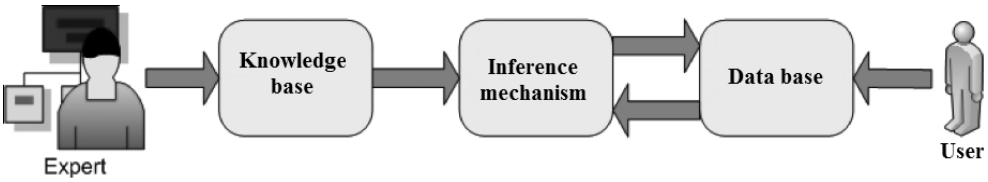

Figure 1. Knowledge base system architecture

3.1 Related Work

The main utilization of expert systems is in the field of medical science, agriculture, biology, biochemistry, computer science, mathematics and many others. An extensive overview of knowledge system utilization is described in [6]. They are also used in the embedded knowledge systems, the implementation of which is devoted to [8]. Knowledge systems are widely used in problem resolving scenarios like troubleshooting or artificial intelligence simulations. Currently, there is project decision support system for wool classification that uses expert system [1].

4 Proposed System Architecture

Our solution consists of several components, namely embedded system device, sensor modules, knowledge base system, data acquisition system, archiving system and user

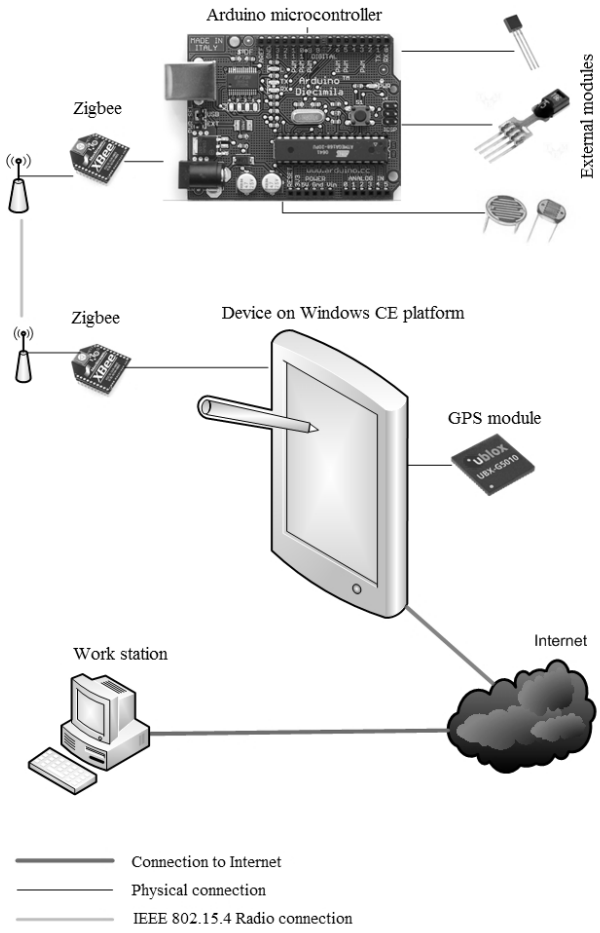

Figure 2. Hardware architecture

interface. The basic hardware architecture is displayed on the Figure no. 2, while the data flow of the whole system is displayed on the Figure no. 3.

4.1 Data Acquisition System

Sensor modules are connected directly to the data acquisition system. Main part of the data acquisition system is Arduino[1] micro-controller. We decided to use micro-controller to process analog and digital signal instead of stand-alone A/D converters, because of it being a more flexible and universal approach. It captures digital and analog data from sensor modules (currently we have sensors to retrieve temperature, air humidity,

[1] `http://www.arduino.cc/`

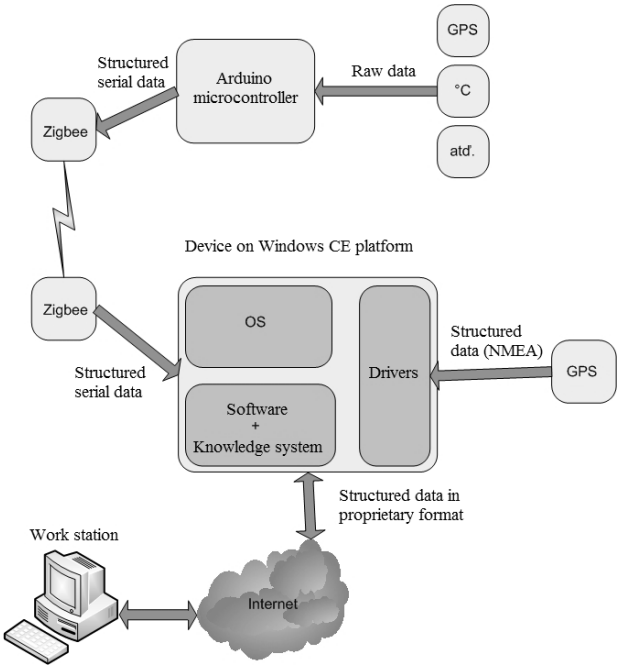

Figure 3. Dataflow Diagram

dew point, luminance, GPS localization and altitude data, while we are also planing sensors for soil moisture, soil acidity, etc), processes it to legal format and transmits the formatted information to the embedded device via wireless or serial interface. This data acquisition system will be interconnected with the embedded system via a wireless ZigBee module. For our implementation, we have chosen the XBee 802.15.4 Pro ZNet 2,4Ghz module[2], mainly because of its very low energy consumption and long range.

4.2 Embedded System

The embedded system device will be build on DevKit8000 Evaluation Kit[3] development board with 600Mhz ARM Cortex-A8 processor[4]. Our assignment requires a Windows CE operating system to be run on the given system and this one of the reasons why we have decided for this development board kit – it is one of very few evaluation boards which have board support package for Windows CE 6.0. Besides other useful things, it has SD/MMC interface, Jtag and camera interfaces, and supports up to 128MB DDR RAM as well as USB Wifi and GPS through additional modules.

[2] `http://www.sparkfun.com/datasheets/Wireless/Zigbee/XBee-Datasheet.pdf`
[3] `http://www.embedinfo.com/English/Product/devkit8000.asp`
[4] `http://www.arm.com/products/processors/cortex-a/cortex-a8.php`

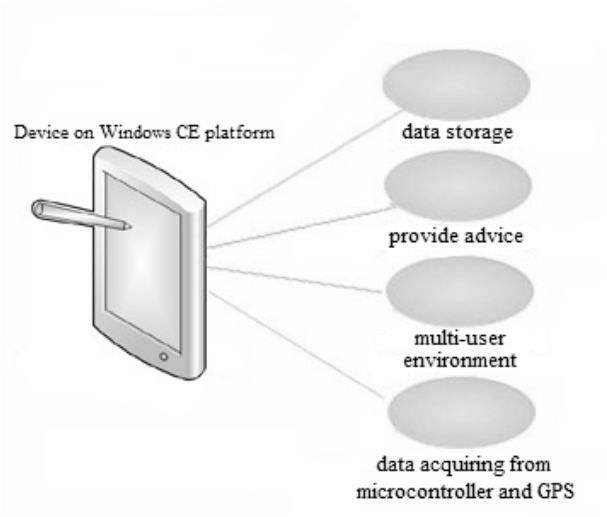

Figure 4. Embedded Device Use Case Diagram

The embedded system interfaces with external entities via various I/O ports, e.g. UART, GPIO, USB and SPI. Its purpose is to run the knowledge base system, as well as to gather data from the data acquisition system as displayed in Figure no. 4. The obtained data is to be stored in the MS SQL Server running on the embedded system. Furthermore, it provides user interface to allow user to set preferences which influence the decision process. Afterwards, the acquired data and user preferences are transferred to the knowledge base system as additional input facts. The knowledge base system is based on the CLIPS[5] building platform, which has to be ported to the Windows CE environment as there is no existing native support.

Embedded device will include a touch screen display. The user interface implemented in the Windows CE environment will guide the user trough series of wizard screens enquiring his preferences and other needed information and options. The user will be able to start and stop data gathering, browse trough gathered data and obtain suggestions with explanation of reasoning process. He will also be able to synchronize the device with the PC application. The main requirements of the user interface are intuitiveness, effectiveness and usability.

4.3 PC Application

The PC application will be focused on archiving of gathered data and results of the reasoning process, displaying them in various graphical representations. The synchro-

[5] `http://clipsrules.sourceforge.net/`

nization is designed to be handled by MS SQL database synchronization between PC application and the embedded system itself. The two will be interconnected via IP network to provide a way to communicate with each other. The PC application will also be able to update or change the knowledge base on the embedded device to keep the system up to date and to ensure system reliability.

5 Conclusion

This paper describes our research in the field of Portable Embedded Decision Support System. Our proposed solution to this problem is an embedded system device built on energy saving modern hardware technology, incorporating the features of knowledge base systems providing a multi-purpose portable device. We believe, although in the very early stage, this device will serve as a useful utility for farmers.

5.1 Future Work

To date, we have partly built the data acquisition part of the system and are currently waiting for the delivery of the development board. We built the operating system part of the device and implemented the prototype of the PC Application user interface.

The future work includes the finalization of the proposed system, i.e. hooking up the data acquisition part to the embedded system as well as its testing. One of the main tasks will be to port the CLIPS platform to Windows CE, build the knowledge base and implement the decision rules.

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References

[1] Dlodlo, N., e.a.: A decision support system for wool classification. *Autex Research Journal*, 2009, pp. 42–46.

[2] Glen, J. J; Tipper, R.: A mathematical programming model for improvement planning in a semi-subsistence farm. *Agricultural Systems*, 2001, p. 70: 295–317.

[3] Jacson, P.: *Introduction to Expert Systems*. Addison-Wesley, 1999.

[4] Kaklauskas, A.; Zavadskas, E.: Decision support system for innovation with a special emphasis on pollution. *International Journal of Environment and Pollution*, 2007, p. 30(3–4): 518–528.

[5] Kurlavičius, A.: Sustainable agricultural development: Knowledge-based decision support. *Baltic Journal on Sustainability*, 2009, p. 15(2): 294–309.

[6] Liao, S.H.: Expert system methodologies and applications - a decade review from 1995 to 2004. *Expert Systems with Applications*, 2005, p. 15(2): 294–309.

[7] Martins, M. B.; Marques, C.A.F.: Methodological aspects of a mathematical programming model to evaluate soil tillage technologies in a risky environment. *European Journal of Operational Research*, 2007, p. 177(1): 556–571.

[8] Pohronska, M.; Krajcovic, T.: Implementation of Expert Systems in Embedded and Real-Time Systems. *Proceedings of the Tenth International Conference Informatics*, 2009, pp. 259–264.