Case Studies in Software Design

# The role of sensors in agriculture

Agricultural production is an increasingly precise industry. The quality and commercial value of the final product is dependent on many factors and careful measurement and monitoring of these factors is important for both the producers and buyers of a crop. Consequently, there is growing interest in the use of sensor technologies both for measuring key crop quality parameters and for monitoring the state of the environment (soil condition, temperatures, moisture etc.) as crops are growing.

In this case study, your team are bidding to ADMMEU, an engineering systems company, for the contract to develop their core software for product line that will use multiple sensors in the agricultural sector.

* The first stage of bidding is to develop a design for your software that offers both the functionality to address existing uses of sensors in agriculture, as well as providing high levels of usability for farmers and for food processing companies working with different crops and in different environments.   
  The deadline for this design is Friday 27th November 2015.
* In the second round of the contract competition a team of software developers will use your designs to develop, test and evaluate a simulator for your software platform that demonstrates both the usability features and the flexibility of the system to be configured to address different ranges of sensors and different agricultural environments.

In the first phase, you are required to demonstrate your understanding of the domain by creating a software functional design (using UML) and user interaction designs for the software.

# About the case study:

Agricultural sensor data is useful for many different purposes. For example, the value of a crop of peas depends on their weight, oil and moisture content when they are harvested and on the time that the peas take from harvesting to freezing (typically achieved in a few hours). Ensuring the best possible balance of quality and quantity relies on precise decisions about the use of fertilisers, pesticides and irrigation, responding to changes in the weather (hours of sunshine, rainfall etc.). Companies that process, package and distribute foodstuff are also concerned about managing a steady supply of high quality produce. For example, a frozen food company will need to keep its production line running constantly at a steady pace, and so will need to schedule the harvesting of peas from different fields to maximise efficiency and quality. This involves predicting the likely weight of peas that will be delivered from each field, and managing the timing of harvesting and transport.

The central idea for the product line that ADMMEU are developing is a ‘field station’. A field station will gather data from different types of sensors which are grouped together. Some field stations will be permanently located in one place (e.g. a field). These may be connected to multiple sensors in that location, and will intermittently collect data from their sensors (e.g. soil moisture sensors, soil temperature sensors, air temperature sensors, soil acidity sensors, lights sensors to measure sunshine etc.). Data will be collected from different sensors at different intervals (e.g. temperature data may be collected every few minutes, sunshine intensity every minute, but soil acidity might be measured only once per day or less frequently). Different types of sensor data may also be handled differently. For example, cumulative information about sunshine and rainfall over particular periods will be needed, whereas maximum & minimum values may be more relevant for data such as temperatures, and barometric pressure measures may demand an assessment of whether the pressure is ‘falling’, ‘rising’ or ‘stable’ based on trends over a defined period. The US Federal Meteorological Handbook specifies that:

At designated stations, the pressure calculated for each report shall be examined to determine if a pressure change is occurring. If the pressure is rising or falling at a rate of at least 0.06 inch per hour and the pressure change totals 0.02 inch or more at the time of the observation, a pressure change remark shall be reported

When field stations are set up, GPS data will be used to map out the area that the field station is monitoring. Data collected at the individual field station will be reported to servers using the mobile phone network, and will be made available to farmers and food processing managers in different forms using different devices. Data may be presented using geographical information systems to present maps, as well as presenting information about how readings have varied over time. Some data could be used directly to trigger automated responses (e.g. some crops may be provided with automated watering systems, and fertiliser application may be varied within a field to respond to local differences in drainage and soil quality). ADMMEU are also interested in the possibility of a ‘portable field station’ that can be taken to a location, used to collect particular data (e.g. moisture content of the crop, oil content of the crop etc.). Readings taken using the portable field station will also need to be linked to the position where the readings were taken.

ADMEUU systems are concerned to have a varied product line ranging from small scale field stations with a few simple sensors that can attract small farmers to explore how the technology can be used, to large scale integrated systems that handle a wide range of sensors, and are suitable for large industrial farms using ‘precision agriculture’ approaches. They are also aware that the range of sensor technologies available is gradually expanding and so their software must be flexible enough to allow for new types of sensor as well as permitting their ‘field stations’ to work with sensors developed by other companies. ADMMEU systems also see some potential for the ‘field station’ architecture to be integrated with agricultural measurement and monitoring equipment that is manufactured by other companies.

## Existing Systems

A lot of sensor based data collection and testing equipment is already available in the agricultural sector. Different types of crop give rise to different needs. Here are some example products and systems that could benefit from using your software for control:

<http://www.agriculture.com/machinery/precision-agriculture/soilmoisture-senss_234-ar42409>

<https://www.youtube.com/watch?v=aKrADoaI33I> uses a mini harvester to collect samples for this multitest kit: <http://www.gode.fr/uk/default.asp?rub=7&srub=30>

This device is fitted to a combine harvester to measure the yield in a field as it is being harvested: <http://loupelectronics.com/products/yield_monitor.html>

Immediate weather data is always important for farmers, so devices like these weather stations could be developed using the new software architecture: <http://agrisupplyservices.co.uk/weather-stations.htm>

Wikipedia provides a general discussion of the area of ‘precision agriculture’

For a discussion of where agricultural sensor technology is heading, take a look at:

<http://www.sciencedirect.com/science/article/pii/S1537511012001419>

## 5 Final Thoughts

The information in this document is typical of what you might expect to get from a client in industry when developing software systems, i.e. incomplete, possibly ambiguous, and certainly vague.

You are also encouraged to talk to the module delivery team during tutorials to clarify any queries you might have as you design (and then implement) a working system.

Remember, your clients will rarely be computer savvy and it is your job as practicing software engineers/computer scientists, to interpret the English language musings into formal designs and ultimately a software package. If the client could do this, they wouldn’t need us.

## Your design documentation should include:

|  |  |
| --- | --- |
| Element | Marks available |
| 1. A class diagram that covers the major classes used in the system, their relationships and the type signatures of their most important methods | 6 |
| 1. Text to support your class diagram explaining how the major responsibilities of the system have been allocated in your design (this might take the form of CRC cards) | 3 |
| 1. A set of three sequence diagrams which show how the objects in your system will collaborate to implement the more complex use cases in the system.  In particular you should include a sequence diagram that shows how a reading is to be collected from a rainfall sensor and the information is presented in some integrated display for a farmer. You will be required to talk through these sequence diagrams and explain the decisions you have made. | 9 |
| 1. Consistency between division of responsibility, class diagram and sequence diagrams | 2 |
| 1. A set of 3 personas that represent different types of users of the system | 4.5 |
| 1. A set of 3 scenarios that illustrate issues that might need to be considered in developing a useful and usable interaction design | 4.5 |
| 1. A set of 3 high level concept designs that illustrate distinct alternative ways that users could interact with the system | 4.5 |
| 1. A set of 3 detailed storyboards that specify interactions for particular parts of the system so as to ensure a high level of usability. Your storyboards should deal with at least two different types of user | 4.5 |
| 1. Consistency of the storyboards (item 7) and the UML model (items 1 & 2) | 2 |
| TOTAL | 40% |