The Development of an Accessible Web-based Quantum Transportation Device for Older Users

| **Stephanie Lee, Thomas Butterwith, Kurtis Mulgrew, Ron Schoenberg**  **Final Year Industrial Project**  **BSc (Hons) Applied Computing**  **University of Dundee, 2014**  **Prof. John Arnot**  Converted to a PDF file. The report should not exceed 15,000 words or 15-20 pages in length (excluding appendices). What is required is quality rather than quantity. The report should be written in a formal style: it is neither a diary nor a magazine article. All references should be cited in the main body of the report and a standard referencing format (such as IEEE or Harvard style) should be adopted [1, 2]. The report should demonstrate that the student has used appropriate tools to support the development process and that verification and validation have been applied at all stages [3]. The report as a whole should include a clear description of the lifecycle stages undertaken and must describe the use of appropriate tools to support the development process. It should give a full and accurate description of the work done and achievements made, together with complete software documentation and a user manual. |
| --- |

***Abstract* –** The potato plant is the fourth most grown crop in the world and therefor a significant portion of the world’s food production and feeding basis for cattle. There are more than one hundred known diseases and pests which threaten the potato plant and have had dramatic consequences in the past. The James Hutton Institute in Dundee, Scotland, has asked us to design a diagnostics application for smartphones which enables an unexperienced and/or unskilled user to identify pests and diseases in both the tuber, leaves and stems, with appropriate guidance and troubleshooting upon identification. The project case study focuses on farmers in Malawi. The application is therefore aimed to help those farmers specifically. This includes catering to internet access standards, smartphone types and language barriers. The finished product fulfils all the essential requirements and enables non-technical access to the application database as well as an intuitive interface and concise help upon identification. *The abstract is an important part of your report. In essence, it is a summary of the purpose, methods, findings and conclusion of your project. It should be no more than 200 words. It should be clearly and concisely written. Provide only the most pertinent information, avoid citing references and include a brief statement of your main conclusions.*

# Introduction

This section should introduce the project. It should include an explanation of the problem and the objectives of the project.

The potato plant has played a central role in the world’s nutrition ever since it has been exported from the South American Andes and is the 4th most important food crop after Rice, Wheat and Maize [1]. The potato plant tuber, the edible portion of the plant, is very perishable in comparison to other mass-nourishing products minimising export and trade with potato tubers. This limits the uses for the tuber to direct consumption, livestock feeding and starch production. Regardless of the intention for potato farming, the potato is susceptible to a wide range of diseases which can have a dramatic impact on the yield of the farming and has had impacts on entire nations such as Ireland in 1740-1741 [2]. While the knowledge and use of pesticides and the knowledge about diseases have increased ever since the famine, it is still crucial to educate farmers and provide easy identification tools, especially to farmers in developing countries who face the same diseases but lack access to pesticides and expert knowledge.

This project aims at creating an initial diagnosis tool for potato diseases and pests for farmers in developing countries who have no easy access to Microbiological diagnosis tools, the internet, pesticides or professional on-site help.

# Background

This second section would normally include a review of relevant literature and any similar products. The project should be placed in a wider context and this could include the scientific, technical, commercial, social and ethical context.

Current analytical tools for disease and disorder identification are the LFD field test, the FTA card test, two smartphone applications for site testing, and regular textbooks.

The LFD test works similar to a pregnancy test in that it provides a quick way to test a leaf sample for a single trait of a disease. The advantages of this test are the instant feedback, the quick application, the low cost and the versatility as it can be carried and handled in the field. The drawbacks of the LFD test are, that a single test only tests for a single trait and there are hundreds of potentially devastating diseases. This could mislead a farmer into classifying a disease as a harmless anomaly due to an irrelevant or misinterpreted test.

The FTA card test consists of a cardboard envelope onto which the farmer presses up to four samples of leaves or stems. The cardboard is pre-treated to conserve the genetic matter for up to a decade, allowing the card to be sent to an institute with an appropriate DNA tester. The farmer would then receive an information package about the disease or pest with guidance on how to handle the problem. The benefits of the FTA card are, that the card is small and therefor easy to ship worldwide as well as cheap to produce. The DNA sample on the card can be thoroughly analysed to identify any traits of any known disease and the result of the test will be as exact as the current technology enables. The drawbacks are the time it takes for the feedback to arrive, as it could take weeks for the delivery of the card from remote areas, and extended times to analyse the sample. Also, the plant sample has to be squished onto the card, making the application non-intuitive and prone for contamination if applied on the ground in the field. The FTA card test is therefore the most precise test, but also the test which requires the highest concentration from the applicant as it may otherwise be contaminated or provide an insufficient data set to analyse.

A quicker alternative to the FTA card is an on-site evaluation of the plant, tuber or pest with the help of a smartphone application. The International Plant Nutrition Institute (IPNI) offers an app which allows the identification of diseases in multiple crops [3], but only helps identify lacks of nutrients, and does not give suggestions to pests or diseases. The currently only alternative is "Potato Pests" by Leah Tsror, an Apple Application which lists and gives information about Diseases [4]. The benefits of this application are, that diseases are described accurately and symptoms are described in a detailed manner. Drawbacks are, that the user is expected to know the name of the requested disease prior to using the application and that no advice is given to the user upon successful identification. The application is therefore not a useful first-diagnosis tool, but rather useful in combination with the FTA card, when the name of the disease is known and further education on the symptoms is requested.

More common techniques for evaluation are textbooks and field guides. While there are several editions in multiple languages, the range of examples in each book is fixed and updates in research require buying a new edition. A textbook will hardly fit into trouser pockets, making them largely unavailable and unpractical in the field.

It can therefore be concluded that a smartphone application is a useful format for a field diagnosis as smartphones are widely abundant in first world countries and surprisingly common in developing countries. Even the matter of internet access is not the unimaginable task it seems to be in developing countries, as most people will have access to the internet in public places, despite a common lack of electricity at home. An application can therefore be kept up to date with updates and the present phone is given an additional task with an application for disease and pest identification.

# Specification

Specification of the problem and an explanation of how you arrived at this specification. An initial work schedule including an overall project plan with time-scales, deliverables and resources should be included in the report.

The problem identified is, that there is no quick way for an uneducated farmer to analyse a potato disease or pest in the field, as all the existing techniques require either external input or expert knowledge. The product in design may therefore not rely on external input, except for acquisition and updates, and may not rely on the assumption of expert knowledge or further input.

**Initial Work Schedule**

The timescale of the project is a 3 week period in which the entire research, planning, creation and evaluation cycle will be completed. As an agile approach was selected for the development of the project, production started early within the first week as a means of concept and feasibility testing. Key cornerstones of the project scope were the design of the database, the limitations of the XML protocol and the application implementation of the dynamic XML parsing GUI builder. The initial goal was to have the shell for the website, the database and the application done for the midpoint of the sprint duration to grant sufficient time for optimization, debugging and thorough testing.

The normal provision for the Industrial project aims at having teams of five computing students, with some teams of six to amend for incompatible student numbers in the module. Due to a no-show and an unexpected graduation, we started off planning with six people, but ended up with four group members. This enabled us to pair up into programmer pairs and tackle tasks in teams. The first week was spent in pairs creating the website and database as well as the application and xml parsing respectively. The second week was focused on combining the two projects and getting the core functionality running, while the third week was dedicated to design optimization, debugging, testing and project management. The key milestones of the project were the final deadline on Friday the 3rd of October, and the half-way meeting with the client on Wednesday the 24th of September. While the objective for the final presentation was clear, we aimed at having a first running version ready for the midpoint meeting in order to gage feedback and present design concepts.

While the work in programming pairs was clearly divided along the margin of website and application throughout the first week, the pairs split and regrouped for the remaining time as the products had to be combined and project management required independent work on the backlog and report. The last week involved optimization of all members on specific portions of the product as well as input for the report and the presentation from all members.

# Design

Descriptions of the (user-centred) design methods employed to produce a usable product, including rapid prototyping, usability methods, results and re-designs as appropriate. Design decisions and trade-offs should be described, e.g. when selecting algorithms, data structures and implementation environments or when designing for usability.

We designed the application on a cooperative design foundation, assuming that the user and we, the designers, are on a similar level of experience when interacting with the application and website. The presumption was made on the basis that we, as computing students, know very little about potato plants that exceeds the store product. It is that same basis of knowledge which we assume the farmer in Malawi, who may not be aware of the different kinds of diseases, but rather just aware of an ill plant, could possibly have. There is a high probability that the average farmer knows a lot more about the diseases of the potato than we do, but we assumed that no knowledge is present to be able to cater to those that need the advice from the application the most.

For the web interface, we assume that the data entry and editing will be performed by computing professionals with similar knowledge of databases as we have, meaning we can tolerate drawbacks in design if it benefits the efficient manipulation of the database. This thesis is backed by the customer who ensured that all data manipulation will be done by computing professionals.

We settled for the development of an Android application due to the availability of cheap android devices as oppose to highly expensive devices from Apple. It was discussed to provide a windows Phone implementation as well due to the involvement of Microsoft in Developing countries through offering windows surfaces and phones for promotional prices. The decision to not develop a Windows Phone application was made on the basis of time constraints and the desire to produce a reliable and thoroughly tested product rather than two buggy and untested products. From customer information, it is also known that android phones are widely spread and popular amongst the population of Malawi. This means the application can cater to a large user base instantly without requiring expensive hardware changes.

**The Data**

We decided to use a database which holds the disease and symptom information as oppose to a text file or other data structure which would not allow the same extents of scalability as a database would. The database type chosen is a SQL type, as concurring database types such as Cassandra cater to large data amounts, and only excel in efficiency if used on very large data sets, which this application will never reach, even if all possible future extensions are considered.

The SQL database has two tables, one for the Diseases and pests and one for the symptoms. The database design allows for easy entry of new data and uncomplicated altering of existing data. The most important quality of the database is easy querying of the data and conversion of the content to XML code, which can then be downloaded to the application from the application website.

A typical SQL database also allows unplanned queries through the linking of tables, enabling alternative uses for the database possible in the future as opposed to singular use through design-restrictive database types such as Cassandra.

**The website**

The websites purpose is to enable the administrators of the application to add, edit and delete data from the database. The website is not intended for regular customer/user use and does not display data in an intuitive or readable format. This could be changed in later versions of the website, but is not currently implemented.

The current website features a login feature designed to protect the content from unauthorized access as well as ensuring integrity of the data through limiting the editing rights to trained staff. The core content of the website is menu from which the user choses whether to add new data or edit or delete existing data. Once the changes are saved, the database will add a timestamp to the changed content flagging them for the next update whenever a user checks for version updates to the current application. The design of the website is currently not aimed at a wide crowd of editors and contributors, as it is list based and does not provide an intuitive user interface. The customer statement to the matter is, that only one or two professionals will edit the application content, and therefore use the website, meaning that upon training, these professionals can edit content correctly and likely more efficiently than through a complex user interface which would provide the same functionality.

**The Application**

The purpose of the application is to allow the user to navigate to a potato disorder or disease easily, given only a couple of symptoms visible to an amateur. While the easiest option would have been to provide a list of all the diseases and have the user chose the relevant one, it would have been hard to handle with more than the initial 20 diseases and therefore not scalable. We therefore settled on the idea of a decision tree which is modelled around symptoms. The user starts out on the home screen of the application and is prompted with three categories such as "Pests", "leaf Symptoms" and "Tuber Symptoms". With the sample size of diseases reduced to one third, the user is prompted with the next layer of granularity such as "is the leaf crinkled or spotted". Each question reduces the available number of diseases and eventually guides the user to a narrow selection from which to choose. The greatest design challenge for this stage was to accommodate for multiple different symptoms which are all traits of the same disease, meaning that the database must accommodate for multiple symptoms for each disease, namely a linking table allowing multiple relations for single diseases.

At the end of the decision tree, so when hitting the finest granularity which will leave only a couple of options to choose from, there will be a link to a detail page for a specific disease or pest. This detail page features all the data given from Prof. Lesley Doctorons with hyperlinks to further information. The information pages feature a design which aims to deliver data in the easiest possible fashion and avoids unnecessary confusion by first presenting descriptive and informative text for the disease followed by example pictures of symptoms which the user can compare to the example in hand.

The first application design created was a wireframe prototype of the android application layout (Figure 1), which was revised roughly, but quickly agreed upon as the best basic design.

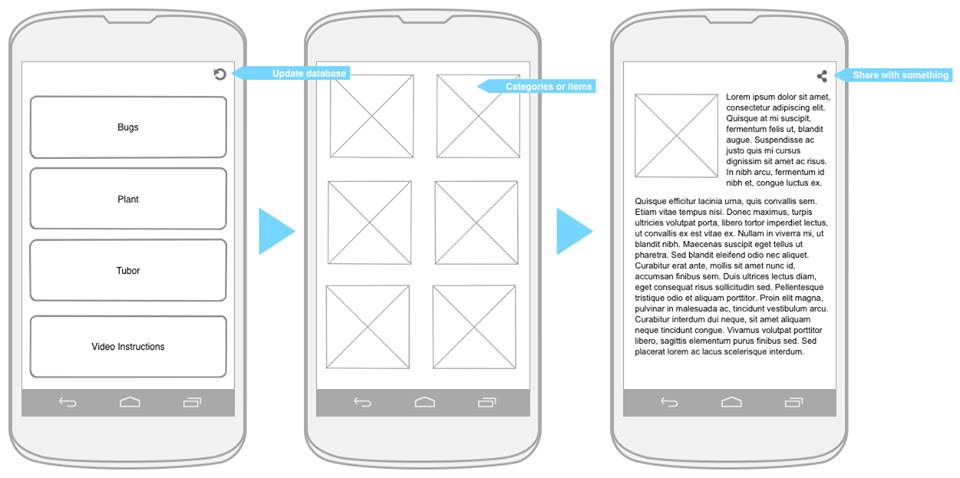


Figure 1. The Initial Application Wireframe Design

The only notable difference to the final application design is the significance of the menu screen (Figure 1, far left screen). This screen will be replicated and customized according to the database dynamically.

The main difficulty in the application design is the dynamically changeable structure of the symptom-driven decision tree menu. Since the structure of the tree could change with every update of the application database, it is important to have a menu page design which accepts one or many options as opposed to a fixed amount of links. Future extensions might involve an overview of the remaining diseases and pests within the selection, as the current design requires the user to navigate to the end of the decision tree regardless of the number of remaining options

**The Update Function**

For the future existence and development of the app, it is vital that the app can be updated to keep up with current research and provide the best analytical options for a quick field diagnosis. For the purpose of updating the application contents, a timestamp has been added to all data in the database which is updated every time that data is created or changed. The user is given an update button on the home screen of the application through which the timestamp of the users’ last update is compared with the data in the database. Every item in the database which has a later timestamp than the users’ timestamp, is downloaded to the user application. The user application is then recompiled, creating the (possibly) new structure of the decision tree to incorporate the changes of the update. While the downloading of the files and the recompilation of the app structure take a lot of time, it is by far the best way to update the application, as downloading the entire structure every single time a change is made would take up much more time and resources and be potentially unnecessary, as changes might not change the layout of the decision tree at all. It is also incredibly inefficient to delete all images in the application, to then download all images again, even if no image was changed, or just a few images were added.

The greatest unexpected complication experienced was the insertion of data into the database. While the data was provided entirely by the James Hutton Institute, the insertion proved difficult due to the creation of the symptom-decision-tree, which had to be created within the symptoms table of the database. This task was only accomplished after we laid out the different diseases and symptoms and created a physical decision tree which we could model in the database. This will likely be a consistent problem for future additions to the database, as the website interface does not provide a graphical representation of the data. The solution to this complication could be to offer a graphical representation of the decision tree on the website allowing the insertion of nodes and menus graphically, or to provide a digital map of the decision tree as a visual aid. While the former could be implemented in the future, the latter proved to work well during the insertion of the primary data. A third possible solution for the addition of data to the decision tree, is a smartphone application which allows the insertion of menus into the app directly, creates the xml representation of the decision tree from the menu structure, and updates the database accordingly. It ws deemed too complicated though, as the web site already exists and could be altered easily to facilitate edits.

# Implementation and Testing

You should describe important aspects of production, testing and debugging.

Kurtis and Thomas paired up to design and develop the Database, Website and XML functionality while Stephanie and Ron shared the development of the Application, the XML parser, Ethics Applications and Project Management.

The developing pairs split up after the first week to focus on uniting the product portions and allow the focus of individual team members on the project organization and presentation planning.

The first functional version of the product was finished in the middle of the second week, so at the halftime of the project duration, leaving sufficient time to add data and test the functionality thoroughly. We found several minor bugs in the application during the beta testing phase such as invisible or hidden menus which were meant to be visible, text exceeding the previsioned space for the text and hyperlinks which weren't in the correct and usable format. The only greater bug found is, that if the update is not completed, the timestamp is not going to be updated partially, as the data is also not added in a sorted manner. This means that, if the user has a connection difficulty or the update terminates for any other reason, the downloaded data is ignored when the user tries to update the application in the future. A solution for this problem would be, to sort the data to be downloaded by timestamp and keep track of the latest downloaded timestamp. The user application would then obtain that last downloaded timestamp and could resume where the download terminated. Due to time constraints we did not include this functionality in the first version of the application, it could however be done easily in future sprint iterations.

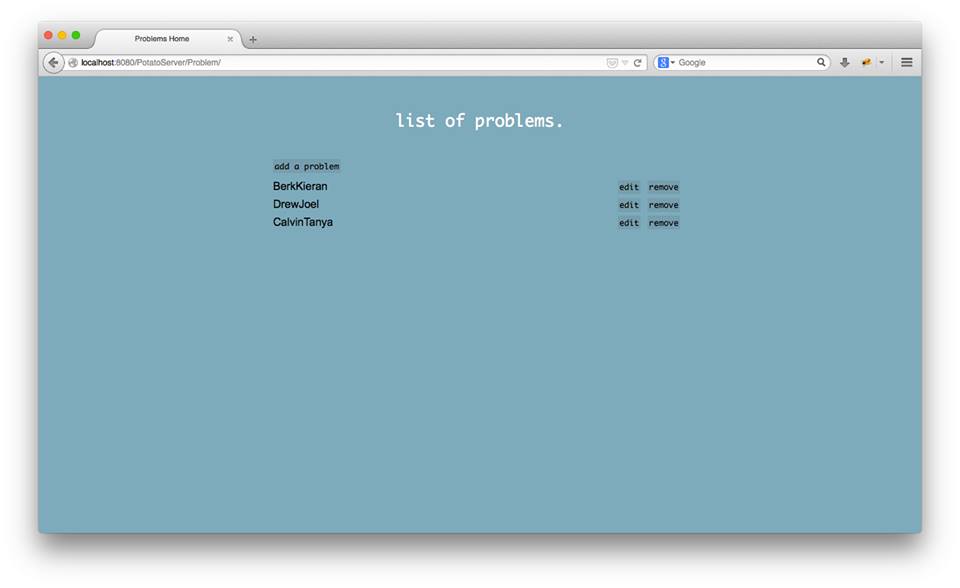
For our user testing, we were unable to contact actual potato farmers. We finally concluded, that we did not need or even want an educated and skilled potato farmer, as they were not necessarily the target group for the application. Given that the application is aimed at unskilled farmers who lack knowledge about the diseases their potato have, we resorted to testing the application with subjects who had very limited knowledge about farming. Through this user testing, largely performed on computing peers, we found that the application concept is sound, as it allows the navigation to certain diseases from symptoms only, as required by the customer. A suggestion we got from one test user was, that the granularity is often very exact, but also very tedious. So while there might only be one choice of a submenu within a menu, it still has to be opened to reach the disease page. This means that the user has to potentially navigate multiple symptom pages with only one option on each page, leading to a single disease. The solution we thought up for this problem is, to show all remaining results in a subsection below the menu options, to enable a direct skipping to the disease as oppose to forcing the user to navigate to the bottom of the menu. For time constraints, we did not implement this feature though, as it also meant to add an entry of each disease to each page of the parent symptom tree during the dynamic creation of the decision tree. The final product design would then be, that all diseases or all pests are shown when taping the "diseases" or "pests" button, and each sub question reduces the number of options left. This design may prove cluttered in the future if the application is scaled to several hundred diseases, but could again be solved with a limiter reducing the number of displayed results.

Figures 2 and 3 show the first functional version of the website:

Figure 2. Initial Content page

Figure 3.

Figures 4 and 5 show the finished and functional website with an appropriate design and layout for data manipulation:

Figure 4. Content page with final design

INSERT SCREENSHOT OF PAGE

Figure 5.

Figure 6 shows the final application title page with the initial navigation options and the update button. This page also links to two web based videos for the use of the FTA card test and the LFD test.

Screenshots of Application title page

Figure 6. Application Title Page

Figure 7 shows an example of a navigation page as it would be found when navigating from the title page to a subsection and symptom. These pages are created dynamically after an update is completed and the number of links may change.

Screenshots of navigation page

Figure 7. Sample application navigation page

Figure 8 shows an example of a content page. The content page holds a description of the disease or pest, other symptoms if Applicable and suggestions for the user in order to get rid of the disease or pest. This page also shows a series of pictures for the disease or pest to serve as a visual aid and facilitate diagnosis.

Screenshots of Disease page

Figure 8. Application Content page

The specifications for the application were vague as the customer only had a rough idea of what the app could or should do. While the customer was definitive about the symptom driven search, other ideas were proposed to the class as suggestions rather than mandatory requirements. Example suggestions which were deemed too complex for the project duration were optical recognition of pests and diseases or voice recognition and analysis for spoken symptom descriptions.

Keeping in mind that the entire project duration including debugging and testing was only 3 weeks, the user specifications were followed and achieved to a high level of detail. The application successfully allows navigation and diagnostics and will be scalable over a long period of time with quick access tools to the database system of the application. The only notable drawbacks are the functional design of the web-interface for data manipulation, which could easily be reviewed to provide a structure as it is found in the application to allow visualization for the administrators. Beyond that, the application will adjust to the data in the database allowing changing and developing content over a long time scale requiring minimal attention.

**Testing**

For the application testing, we finished a working version of the application with 20 diseases and pests. In order to be able to obtain quantitative as well as qualitative data, we devised two tests for the user.

Test number 1 consisted of two runs in which the Subject is given a picture of a potato with Nematodes and Late blight with the aim to find the correct disease definition. During this test we were able to both observe the users interaction with the application as well as record the time the user took to reach the correct disease and the number of incorrect navigation attempts and false diagnosis.

The following table, Table 1, shows the results of the test runs:

Table 1. Results from Subject interactions

|  |  |  |  |
| --- | --- | --- | --- |
| **User # / Run # / Disease #** | **Time for completed navigation (sec. +- 0,5s)** | **Number of incorrect navigations** | **Number of false diagnosis** |
| 1/1/1 | 20 | 4 | 1 |
| 1/2/2 | 11 | 2 | 1 |
| 2/1/2 | 18 | 3 | 2 |
| 2/2/1 | 7 | 2 | 1 |
| 3/1/1 | 18 | 4 | 2 |
| 3/2/2 | 9 | 1 | 0 |
| 4/1/2 | 22 | 4 | 2 |
| 4/2/1 | 13 | 1 | 1 |

Disease 1: Nematodes

Disease 2: Late blight

The data shows the evolution from the first to the second run for each user. It is clear that the users had some confusion during the first run and a couple of false diagnosis. The second run was completed much faster and the number of false navigations and diagnosis more than halved. In order to minimize experimental error, we switched the two disease to be found. This means that users 1 and 3 had to search for Nematodes first, while users 2 and 4 had to search for Late blight first followed by Nematodes.

The qualitative feedback received was fundamentally positive, and the users agreed that the navigation could probably not be more intuitive than the current version. The only concrete suggestion given was, that the navigation categories could include images to facilitate identification instead of the current text-only approach.

More qualitative or quantitative results?

Include a demonstration (or even a proof) that the specification has been satisfied.

# Evaluation

## Usability

The application aims to offer a quick diagnosis tool for potato diseases and pests, and user tests have shown that, after a short introduction and learning phase, the user can quickly navigate to the disease or pests on a potato plant given only a picture of a symptom or pest. Therefore the ease of learning for the application is probably the best is could be, given it took the subjects less than one minute to understand and work with the application. While we produced a video which serves as a step-for-step guide to the application, we think it is absolutely possible to learn the functioning of the application from trial and error.

We concluded that the design fulfils the customer criteria in offering a symptom based search, and we were unable to suggest a more intuitive way of navigating to a disease or pest given a plant sample or sample picture. The design of the menu is held as slick as possible to avoid distracting the user with options or animations.

We believe that the efficiency of use of the menu is both on a very high level, and still open for optimization, as the menu structure can be changed within the database at any time, and even cases of multiple symptoms for the same pest or disease are taken care of in an intuitive way. The efficiency the use can still be further enhanced through the use of pictures in the menu options, and maybe a colour coding of colour symptom options.

We are certain that a farmer, regardless of experience, will appreciate the presence of the application as a diagnosis tool. While a given farmer may know most of the common diseases from experience, it is likely a welcome option to be able to quickly consult an application in the case of an anomaly or to obtain further guidance on an issue. This memorability of the application distinguishes our application from other venders and is likely to reserve it a permanent space on the farmers’ android device.

The error frequency for the application is relatively high at the moment, given a total of 4 false navigations during the second run of each test subject. The test subjects were usually immediately aware of the false diagnostic through the pictures given in the information page, which may be reduced through the further use of images in the menu layers. This means that although the error frequency might be relatively high, the user can always use the back button to return to the navigation menu through which a different symptom-path can be chosen. The assumption for error frequency is, that if there was an average of one error on a sample size of 20 diseases, then there will likely be 5 errors on a sample size of 100 diseases. This error amount could be brought back down to 1 or even 0 with the use of menu-images.

The subjective satisfaction of the users was positive in general, with the basic consent that the application could probably be very useful to the farmers in developing countries who lack access to professional help and technology or even just textbook resources.

## Other criteria

Other relevant criteria such as accuracy and computational efficiency should also be employed for evaluation as appropriate.

**Efficiency Analysis**

The most basic efficiency feature is the use of a decision tree to be enable the user to filter irrelevant diseases and pests leaving only a short list for the user to choose from. The relationship between the number of diseases and pests is logarithmic, therefore the number of menus and submenus will only increase slightly when the app is scaled to the planned 100 entries.

The problem with the application updates was a lot more challenging to solve. The basic solution would have been to publish an update for the application and prompt the user to download the entire application at once and reinstall it. This would have meant to download a potential amount of ~600 images which, even at reduced size, would have meant high traffic volumes and long waiting times for people without Fiberoptic connections. This would have been especially annoying if the update was minor.

The solution was a partial update, through which only the new or changed data is downloaded to the application. This means, that the user will still have to download the entire data set with the first acquisition of the application, but any further updates will only have to download the changes made to the dataset.

# Summary and Conclusions

Summarise the main points and ensure that you have described the final product. Include a critical appraisal of the project indicating the rationale for design and implementation decisions, lessons learnt during the course of the project and an evaluation (with the benefit of hindsight) of the final product and the process of its production (including a review of the plan and any deviations from it). Make recommendations for future work.

The final application offers a quick tool for on-site field diagnosis of pests and diseases in potato plants and tubers. The design it optimized to allow quick navigation and updates of the application to ensure a valid and up-to-date dataset. The application runs on all devices with the latest or related Android Operating System (OS) versions, meaning it will be able to run on most existing devices without reconfigurations and the devices themselves will be of the cheapest category thanks to the open source nature of the Android OS.

While the app works correctly under lab circumstances, the main point of criticism is the update functionality. While it is very sophisticated as it is, any error during the connection will currently require a completely new download of the data. Also, if the user first acquires the application, it will be empty. The user has to update the data when first running the application, meaning that a potential cold start and initial use in the field will be deemed unsuccessful as the data will not be present in the store version.

## Acknowledgments

The group would like to thank the James Hutton Institute for the Images and Information provided as well as the instant feedback received during the development process.

# References

[1] "International Year of the Potato 2008 – The potato" (PDF). United Nations Food and Agricultural Organisation. 2009. Retrieved 26 October 2011.

[2] Gavin, Philip. "Irish Potato Famine." The History Place, 12 June 2000. Web. 23 Sept. 2014.

[3] International Plant Nutrition Institute Apps. *Crop Nutrient Deficiency Photo Library App*. Computer software. *Crop Nutrient Deficiency Photo Library*. Vers. 1.1. International Plant Nutrition Institute, 9 July 2012. Web. 22 Sept. 2014.

[4] Tsror, Leah. *Potato Pests*. Computer software. *Leah Tsror, Ph.D. - ARO*. Vers. 1.1. Apple / ITunes, n.d. Web. 17 Aug. 2012.

# Appendices

The main body of the report should read as a self-contained document. However, appendices can be used for necessary supporting documentation. These should include a user manual, software, source code and minutes of your meetings *in electronic form only* (i.e. on a disc). Hardcopies of appendices should not be submitted.

Website Source Code

Database Creation SQL Code

Application Source Code

Meeting Minutes

IN DIGITAL FORMAT ONLY