Research Proposal
A highly accessible, low bandwidth, cellular-based online student support system
Version 0.2

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1 Overview
This proposal starts from the assumption that Unisa students may not have good Internet connectivity in terms of broadband, ADSL, wireless etc. but are likely to have access to a smartphone or feature phone which allows them convenient access to the cellular network.

The idea is to develop a online system which will allow students to use the sms facility on their phones to download exercises, solutions and examples for the material in their modules. The proposal is that a student could send an sms to the system asking for a worked example of a particular exercise, they could then ask for a new exercise of that type and could then either submit a solution for comment or ask for the solution to that exercise. They could then ask for another similar problem or move on to a different type of problem.

The proof of concept for this tool will be based on some of the material from the Theoretical Computer Science modules COS2601 and COS3701. In particular, we will concentrate on the design and testing of Finite Automata (FA) and Transition Graphs (TG). This is motivated by the fact the students often find mastering these concepts to be challenging – see for example [5, 3].

2 Requirements for prototype
In order to test the idea we would need to have or to develop the following.

1. A cell phone / SIM card linked to some computation system to enable receiving and sending smses.
2. A repository of worked examples, exercises, solutions to exercises.
3. A cataloguing system for the exercises.
4. A tracking system to monitor which examples or exercises a given student has seen.
5. A testing module which determines whether the submitted solution meets the requirements of the exercise.
6. A feedback module which informs the student of where their solution fails (and more difficult makes suggestions on how to solve the problem).
7. A visualisation module which allows the students to see their machine executing on various input strings.

Points 1 to 4 seem to be relatively easily achievable. Points 5 to 7 are more interesting.

3 Research Questions
The obvious research question is:

“Would such a system benefit the students?”
This is allied to testing our basic assumption “What connectivity do Unisa computing students have?” mentioned above.

Other possible research questions or aims are related to requirements 5 to 7 above.

1. “How can we test whether a given solution satisfies the requirements of the exercise?”
   If the solution is a FA specified as a summary table (sometimes called a transition table) then we could obviously test a number of cases. The problem is whether this would ensure that the solution always works. We may need a more formal way of doing this. Whatever testing we do should be done in “real time”. Is this feasible?
   If the solution is a statement in natural language “The FA recognises all words that start with a and have an even number of ab.” then we probably need a different way of determining whether the solution given by the student is correct.
   Could we test a pumping lemma proof?

2. “Can we develop an automatic feedback system?” This clearly depends on the type of solution we are considering but there seem to be significant challenges.

3. “Can we build or tailor a system to enable visualisations on a smart phone or a feature phone?” There are existing FA visualisation systems (see for example [4, 2, 5, 6, 1]) but as far as we can tell none of these is designed to run on a mobile device (if laptop computers are excluded from the definition). We would have to worry about small screen size (especially if we look at feature phones), low bandwidth usage, etc.

4. “Can we build a system to convert electronic versions of hand-drawn FA diagrams to summary tables?” The input here could be scanned or photographed diagrams. There has been some work in converting old line drawings (building plans etc.) to electronic format for incorporation into CAD systems [need to find some references].

4 Specific projects

1. Verify our basic assumption that our COS2601 and COS3701 students are connected to the cellular network. A starting research question is “What connectivity do Unisa computing students have?”. This could be an Honours level research topic.

2. Design, implement, test and evaluate a system that runs on a smartphone that takes as input a FA specified as a summary table and allows the student to test the FA with different input strings. This is essentially prototyping research in CS jargon. (Is it Design Science Research or something similar in IS?) This could be an Honours level research topic.

3. Design, implement, test and evaluate a system that runs on a smartphone that takes as input a FA specified as a summary table and visualises the execution of the FA on different input strings. This could be an Honours level research topic.

4. Improving the above tool to do formal verification that the designed FA will recognise all words and only those words which are in the given language. This could be a Masters level research topic.

5. Determine the common misconceptions of Unisa students when designing FAs. This could be a Masters level research topic.

6. Design, implement, test and evaluate a system to convert hand drawn FAs into a summary table representation. This is a significant challenge from a CS and/or image processing view. As mentioned above there is some existing related work but approaches/techniques will need to be adapted. This is a PhD level research topic.

7. Design, implement, test and evaluate a tool which gives useful feedback to the student based on a submitted summary table or FA diagram. This is a significant challenge from a CS view. This is a PhD level research topic.
8. Design, implement, test and evaluate a tool which takes as input a specification of a language in natural language and produces an appropriate RE, CFG or automata to recognise/accept words in that language. This could be a PhD level topic (it is a bit out of my scope though).

9. Extend the work in any of the projects listed above to work on Transitions Graphs, Pushdown Automata and Turing Machines.

References


