

Digital Assistant for Financial Transactions (DAFT)

A Multilingual Personal Finance Management Application Incorporating NLG

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1 Project Description

Financial exclusion is defined as the incapacity of accessing useful financial services [9]. Fintech products, which are technological products that are dedicated to financial services [10], have seen success in addressing financial exclusion [11]. An example is M-Pesa, which is a mobile money system that helps Kenyans become financially included [12]. Furthermore, it has been suggested that there is a correlation between financial literacy and financial exclusion in South Africa, and specifically at the “bottom of the pyramid” [1]. Financial illiteracy helps people understand the advantages of being banked [1]. Therefore, to address financial exclusion, we need to address financial illiteracy.

Considering the need to address financial literacy and the success of Fintech products in addressing financial exclusion, we aim to create a mobile application that will encourage citizens to partake in the formal banking sector. The platform will act as a facilitator system by educating citizens about financial literacy and communicating insightful summarized information about their financial transactions in an understandable manner. This will be accomplished by incorporating Natural Language Generation (NLG) into the mobile application. NLG is concerned with the conversion of non-linguistic input to an understandable natural language text [4]. NLG has the potential to empower individuals of different levels of expertise to consume and interpret the information contained in tables, datasets with minimal human intervention [3]. NLG has been successfully adopted widely to automatically generate sports, weather, and financial reports. However, systems that can produce such reports for South African languages are few due to the languages being under-resourced [5]. The highly agglutinative nature of these languages renders traditional NLG methods designed for Indo-European languages inapplicable for use [3]. To the best of our knowledge, there are no existing NLG systems that can produce financial reports in isiZulu. It is for this reason that building such a system will be beneficial as it will bridge the gaps between the technology, the finance domain, and the isiZulu language. IsiZulu is the most spoken language in South Africa, spoken by approximately 22.7% [5] of the population, therefore, targeting this group will allow our application to have a greater reach. Smartphone penetration in South Africa was approximately 90% in 2019 [6], therefore, there is a high probability of reaching those who are financially excluded

and financially illiterate by building our solution as a mobile application.

2 The Problem statement, Aim, and Research Question

2.1 Problem Statement

Research has found that some perceive that banks are not transparent enough about the information required to make financial decisions [13]. It was suggested that the problem could be related to how banks are communicating the information and the level of financial literacy of these citizens [13]. Furthermore, a study claims that only 25% of the population has satisfactory level of English skills and that people with low literacy levels usually need help in their mother tongue when they visit bank branches [2]. According to our findings, South African banks offer mobile applications in mainly English and Afrikaans. This diversification of communications helps customers engage with the system in a language that they are already familiar and comfortable with; however, they do not accommodate for Niger Congo B languages. This means that there exists a need for banking services to accommodate various languages.

2.2 Aim and Research Question

To address the underlying problem of financial illiteracy, we aim to build a mobile application that helps people to manage their finances and informs them about the necessary information that they require to make competent financial decisions. Furthermore, to address the resulting problem associated with how information is communicated, which is suggested to be caused by financial illiteracy, we aim to develop a natural language generator that provides insightful information about a user’s financial transaction history in isiZulu, a Niger Congo B language. Our work aims to expand the existing NLG research in Niger Congo B languages by focusing on ensuring that numbers are verbalized in context.

The natural language generation aspect of this work will attempt to answer the research question: How can an NLG system that appropriately verbalizes numbers in any given context to produce understandable isiZulu sentences be built?

3 Procedures and methods

3.1 Mobile Application and Content Determination for NLG

The mobile application and content for the NLG will be developed and determined using the Rapid Application Development methodology wherein each iteration we will adjust the system based on feedback. This type of methodology will be useful to ensure that we produce a solution promptly whilst ensuring user-centricity. The user-centricity is not only beneficial for the interface design but also for the content determination as well.

3.1.1 Mobile Application Features and Content Selection. Initially, we will research and choose an existing budgeting technique that the system will incorporate to help users budget and sort their transaction history. The budgeting technique will help users understand how to become financially literate. The mobile application will also display the transaction history of users and incorporate visual representations of the budget as well as budget summaries generated from the NLG module. The summaries will be based on significant information regarding the budget. The significant information will be brainstormed and decided by the team (i.e., Content selection for NLG component). The combination of the listed transactions, budget goals and budget summaries will provide the users with information that will help them maintain their budgets whilst providing information about how their money is spent in the formal banking sector. These features will be incorporated into an initial non-functional prototype and a functional prototype. These prototypes will be evaluated by the users via questionnaires.

3.1.2 Recruitment and Iterations for Questionnaires For the mobile application and content selection of the NLG component, we will conduct 1 or 2 iterations of at least 10 user questionnaires via LimeSurvey. We will recruit a combination of participants that speak either isiZulu or English. This will be done to ensure that the mobile application and content selection is designed appropriately with the 2 languages taken into consideration. At least 5 of the participants need to be native English speakers and another 5 participants need to be native isiZulu speakers. All other participants of the questionnaires, if any, can be native English or isiZulu speakers. It is preferred if the participant group contains participants with various ages and genders, however, this is not mandatory for the evaluations. Participants will be recruited via email using a mail list from UCT. Recruitment emails will also ask for recommendations and the team will select the appropriate participants to meet our expected quota of at least 10 participants with at least 5 participants being native isiZulu speakers and another 5 participants being native English speakers (i.e., purposive sampling and snowball sampling). Participants will be required to provide their emails in the questionnaires for further iterations of questionnaires. The number of iterations of questionnaires will depend on the responses of participants. The types of questions asked (i.e., questions relating

to application design, application usefulness, application usability, whether the application meets their expectations, and the exemplar output text from the NLG feature) may also be reduced in each iteration depending on responses from prior questionnaires.

3.1.3 User Evaluation of Mobile Application We will ask participants about the design, usefulness (i.e., whether the application features will positively influence their financial literacy) and usability of a linked non-functional mobile application created on Adobe XD in the questionnaires. Videos and/or images presenting the functionality of features will also be added to the questionnaire to evaluate the design, usefulness, and usability of the application. The participants will need to rate these 3 subjects using Likert scales. Participants will also be allowed to provide typed feedback and suggestions about the 3 subjects in the questionnaire. Participants will also rate whether the application meets their expectations via a Likert Scale and will be allowed to provide further typed feedback regarding their expectations.

3.1.4 User Evaluation of Content Selection Participants will also compare and rate the usefulness of multiple versions of exemplar output text (i.e., 1 team suggested version and at least 1 draft version) from the NLG feature in the questionnaires. The users will be allowed to suggest or reword the output in the questionnaire. Since the application will also incorporate a visual representation of data, such as a graph or pie-chart, there will also be a question that will ask users to indicate their preference between both the graph and text, just the text or just the graph. These questions will indicate whether the content for the NLG has been appropriately selected. For the evaluation, the exemplar output from the NLG feature will be based on “dummy” JSON data to represent a user’s transaction history. This will ensure that the mobile application development and evaluation can continue whilst the NLG module is completed. The “dummy” JSON data will need to be generated by the team using a developed JSON data generator.

3.1.5 Final product and System Testing Once the 1 or 2 iterations of user questionnaires are completed and the system is refined according to the feedback from the questionnaires, then the final system will be created from the prior versions of the system. The final system will incorporate the NLG module produced and a Text-to-Speech (TTS) feature. We will continue to use “dummy” JSON data to represent the user’s transaction history in the final system. After the addition of the 2 extra features (i.e., the NLG module and TTS feature), then a system testing will be completed. The system testing will be conducted by the team. A list of system test cases will be created, and each test will need to pass for the system to be considered as acceptable or finalized. The system tests will include functionality testing and interoperability testing. If time permits, an internal team heuristics evaluation will be conducted to ensure that the final system is usable according to the heuristics guidelines.

3.2 Natural Language Generator

The NLG system will accept transactional data of a user as input and outputs a textual summary of the transactions in the data in isiZulu language.

The features of the NLG system listed in order of priority include, producing understandable isiZulu sentences, appropriately dealing with numbers in any given context and producing insightful reports.

During software development many problems can arise therefore an agile development methodology will be followed. This strategy is designed to minimize risk such as bugs, when adding new functionality. This strategy involves building software in small iterations allowing for defects to be found and fixed earlier. During development of the NLG system, we aim to incrementally add features to the system, internally evaluate the system with help from supervisors and based on the evaluation feedback make changes to the system accordingly and repeat the cycle with a different set of features until all the intended features are incorporated.

3.2.1 Corpus Creation. A corpus-based approach will be followed, and isiZulu language experts will be invited to compile examples of appropriate output texts, which will form a corpus. The goal is to be able to verbalize any number between 0 and 9999 isiZulu, this range has been chosen as banks usually suggest a daily transaction limit between R3000 and R5000 therefore base on this fact, it is reasonable to assume that majority of transactions are less than or within the chosen range. The expert/s will be asked to convert a comprehensive set of numbers within this range into words in isiZulu to create a corpus. The expert/s will also be asked to create a corpus of sentences involving verbalization of cardinal and ordinal numbers in context. Experts for our work, can be isiZulu linguists, isiZulu professionals in the finance domain. Emphasis will be placed on ensuring that the examples created by experts are grammatically correct and verbalize numbers appropriately as templates for this work will be built according to these examples.

3.2.2 Architecture. The three-stage modular architecture [4] will be followed, for our work. The modularity of this architecture is appropriate for our work as it allows for work to be easily divisible. The text planner will input transactional data from an API and content determination mentioned above in section 3.1 will determine what information will be included in the textual description based on the transactional data and choose the appropriate words that will accurately describe the data. This list of words will be passed on into the sentence planner. The sentence planner will then accept these lists of words from the text planner as input and decide on a structure of the intended sentence. The output of this module will be a tree diagram that describes the relationship that exists between individual words, sentences etc. The linguistic realizer accepts the tree diagram from the sentence planner and generates sentences that are grammatically correct, understandable, and appropriately deal with numbers in context

using templates created from the corpus and infused with isiZulu grammar rules.

3.2.3 NLG Text Evaluation. The intended users of our mobile application are isiZulu speakers. Once the generator has been implemented a group of 10 participants who are first language isiZulu speakers will be invited to evaluate the understandability of the text produced. The evaluation will be conducted through a questionnaire where participants will be asked to rate the quality of the produced text on a 1–5-point Likert scale. Where 1 Strongly disagree, 2 disagree, 3 Neutral, 4 Agree, 5 Strongly agree. The questions in the questionnaire will be tailored to test whether the system is producing understandable text and whether it is appropriately verbalizing numbers in context. In addition to the Likert scale evaluation, for the verbalization of numbers in context the text produced by the system will be evaluated against text produced by an expert during corpus creation and text from a textbook.

3.2.4 Participants and Recruitment. The determining criterion for participants is that they must be first language speakers of isiZulu. We would like to recruit diverse group participants to ensure that results from evaluation are not dependent on type of participants. Participants will be recruited through the university via email, social media, personal network, and snowball sampling. To grant our evaluation momentum we would like to incentivize participants with an UberEATS voucher worth R50 for their time.

3.2.5 NLG Analysis. After the textual evaluation the results from the Likert scale will be tallied for each sentence produced and the understandability will be judged based on the frequency of each rating or the median. The overall understandability of the produced text will also be judged by tallying the ratings across all sentences in the text. Furthermore, for verbalizing number in context, text similarity tests will be conducted for the text produced by the system, expert and textbook, and the system will be judged to be verbalizing numbers in context based on the similarity of the produced text.

4 Ethical, Professional and Legal Issues

To conduct research that involves human participants will require ethical clearance from the University of Cape Town (UCT) research ethics committee. To obtain clearance, we are required to submit the research ethics statement form and the informed consent form to the committee. After obtaining clearance we are required to inform participants of what the research entails prior to their involvement and obtain their consent. Personal information of participants will be collected to ensure that participants are correctly remunerated. After remuneration personal information of the participants will be deleted.

All software produced by this work will be released under the UCT's policy for the creative commons license.

5 Related Work

Software such as Yseop's Augmented Financial Analyst and the 22seven mobile application both offer financial help to its users [15, 16]. Yseop's Augmented Financial Analyst uses NLG to generate financial reports [15] whereas 22seven helps South African users to ensure that they have a suitable budgeting system [16]. These two fintech products both incorporate the two components that we wish to add to our system, namely NLG and financial management. Another personal financial management mobile application is Mint, which is similar to 22seven but is not dedicated to South Africans [17].

With respect to natural language generation systems in the finance domain, there exists systems with approaches which our work will follow. EasyText is an NLG system that accepts numerical data in tables as input and produces analytical insights about the events in these tables. To produce reports that are understandable and consistent with previous reports the NLG follows the writing styles of domain experts [7]. When deployed in production the customers were satisfied with the produced textual output and this tool was and is still commercialized therefore due to the success of this system in producing understandable text, we would like to adopt its approach. However, research in NLG for the isiZulu language revealed that the highly agglutinative structure, complex verb and grammar rules of this language make traditional NLG techniques used for indo-european inapplicable for use [3]. Although EasyTexts' approach will be followed for the content determination and sentence planning, its approach for realisation will not be applicable for our work. Grammar-infused templates have been proposed as a solution for realisation for under-resourced languages [8], therefore this project will utilise grammar-infused templates to generate the textual summaries.

To the best of our findings, we have not found a multilingual mobile application that incorporates NLG to enhance users' understanding of personal financial management.

6 Anticipated Outcomes

6.1 System

The system to be produced is a mobile application that will collect, process, and analyze financial transaction history of users from banking Application Programming Interfaces (APIs). The application will include a natural language generator that will convert the transactional history data into the textual description equivalent, with a special emphasis on ensuring that numbers are verbalized correctly.

6.2 Design Challenges

Trust is a barrier to financial inclusivity. It has been reported that distrust in banks is a causation for financial exclusion in the poorer population of South Africa [18]. Research has also mentioned that automation can be detrimental to the trust of current banking customers [19]. Benamati And Serva provides an example of the

lack of trust with ATMs [19]. They explain that a customer can rely on a human teller to provide evidence that a specific transaction has occurred, however, an ATM cannot provide this sort of accountability [19]. Since we are developing a system that automates financial management, and hence relates to banks, we need to consider how we can design the system to avoid causing distrust of the application. Furthermore, since we are introducing NLG, which is a sub-field of AI, users may have even more distrust with the overall system as AI alone can cause mistrust [20]. To address the challenge of distrust, we will make use of Human Computer Interaction research to help induce trust through the interface. Such research includes Wang and Emurian's framework that groups various elements that develop user trustworthiness [14]. Their framework identifies four groups of elements, namely "Graphic Design", "Structure Design", "Content Design" and "Social-cue design" [14]. We aim to use their framework to create a suitable interface for the users. In the questionnaires for the mobile application, we will ask users to rate their trustworthiness of the application design using a Likert Scale. This will evaluate if the design has successfully achieved a trust inducing interface.

isiZulu as already alluded to is a highly agglutinative language, with a complex noun class system and is under-resourced for software applications [5], therefore existing solutions and techniques implemented for other languages may not be inapplicable for use. These complexities in the isiZulu grammar rules pose an additional challenge of ensuring that a sentence is both grammatically correct and understandable.

6.3 Expected Impact

This work will produce the first isiZulu NLG system in the finance domain. There is an emphasis on this work to produce an NLG system that can accurately verbalize numbers in any given context for isiZulu, as existing systems in place in other domains are unable to do so.

This work would like to contribute to ongoing efforts to include indigenous language into the formal economy in South Africa, by creating a platform that addresses financial exclusion and illiteracy in South Africa in isiZulu.

We hope that by offering our solution as a mobile application would make it more accessible and that the application can offer customers a similar experience to what they can receive when assisted by a teller at a branch.

6.4 Key success factors

The NLG system will be evaluated by participants and will be judged to be a success based on two factors. Firstly, if it produces understandable isiZulu textual descriptions of the transactional data, secondly if it can appropriately deal with numbers in any given context.

We will conduct an online survey where users will evaluate the mobile application and the NLG component. This will determine whether users feel that the mobile application can help them

manage their finances better. We will also conduct the online surveys with indirect target users of the mobile application (i.e., those who perceive themselves to be financially literate) to investigate whether our application has met their standards of suitable financial management system. Since those who perceive themselves to be financially illiterate may not know what they require from the system, responses from the indirect target users will help us determine if the direct target user responses are realistic, especially if the mobile application is well received by the direct target users.

7 Project Plan

7.1 Risks and Risk Management Strategies

To ensure the success of the project we have identified potential risks to the project and ranked these risks according to their probability of occurring and the impact they will have on the project. We have also devised strategies to monitor and prevent these risks from occurring see appendix A.

7.2 Timeline and Milestones

The project started on the 3rd of May 2021 and is scheduled to end on the 18th of October 2021. The timeline, tasks and milestones of this project are presented in the form of a Gantt chart in appendix B.

7.3 Required Resources

The mobile application will require “dummy” JSON data that represents the JSON data that the application would request from the banking APIs. The “dummy” data will need to be based on existing JSON data developers can collect from existing banking APIs and will need to be generated via a JSON data generator. The generator will be created by the team.

A high-fidelity mobile application will need to be designed on a design tool. For the project, we will use Adobe XD. The functional mobile application will then be produced on Android Studio with Java. The NLG system requires data to be provided as input to generate textual description. JSON data that resembles data produced by banking APIs will be fed into the generator. To produce grammatically correct and understandable isiZulu sentences, grammar-infused templates developed by Mahlaza and Keet will be used and extended to fit our work. The NLG API will be integrated into the mobile application, and therefore is a resource required for the mobile application component of the project. The outputted text from the NLG API would also preferably be vocalised by a Text-to-Speech (TTS) engine. We have received consent to use qfrenzy TTS from CSIR with limited functionality.

7.4 Deliverables

The main deliverable for this project is a mobile application which incorporates an isiZulu NLG component and a TTS synthesizer to

address financial literacy in South Africa. A comprehensive set of deliverables and their due dates for the project are listed in table 1.

| Deliverable | Due date |
|--|-------------------|
| Individual literature reviews | 24 Jun 2021 |
| Project proposal document and presentation | 9 July 2021 |
| Ethics clearance | 12 July 2021 |
| Requirements specification for mobile application (includes content determination) | 10 August 2021 |
| Initial high-fidelity non-functional mobile application design | 13 August 2021 |
| First Functional Mobile Application Prototype without NLG and TTS incorporated | 23 August 2021 |
| First User Survey for the Mobile Application and Feedback | 25 August 2021 |
| Second high-fidelity non-functional mobile application design | 26 August 2021 |
| Second Functional Mobile Application Prototype without NLG and TTS | 30 August 2021 |
| Second User Survey for Mobile Application and Feedback | 31 August 2021 |
| NLG first iteration complete | 10 August 2021 |
| JSON data generator and “dummy” JSON data | 20 August 2021 |
| NLG second and final iteration | 30 August 2021 |
| Final Functional Mobile Application with NLG, TTS and data processing incorporated | 02 September 2021 |
| Text evaluations | 06 September 2021 |
| System testing of final mobile application | 06 September 2021 |
| Drafts of final papers | 06 September 2021 |
| Final project papers | 17 September 2021 |
| Final project code | 20 September 2021 |

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|-----------------------|--------------------|
| Project Demonstration | 4 - 8 October 2021 |
| Poster | 11 October 2021 |
| Web page | 18 October 2021 |

Table 1. Project deliverables and their due dates.

7.5 Work Allocation

To ensure the success of the project, work for the project has been evenly distributed between the two members while ensuring that dependence between members is minimal. Amy Solomons will be responsible for development of the mobile application, and the content determination module of the Natural language generation component. Junior Moraba will be responsible for the sentence planning and linguistic realization modules of the NLG component. Members will work collaboratively to integrate the NLG component into the mobile application.

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APPENDIX**Appendix A: Risk Response Plan**

| Risk | Probability | Impact | Owner | Mitigation | Monitoring | Management |
|--|-------------|--------|--------|--|--|--|
| Delay in determining the content for the NLG sentence planner and realizer due to Amy being having a prime focus on interface design in the initial interviews | Medium | High | Junior | Build the sentence realizer and planner with dummy data and design a realistic schedule for the entire team | Continuous revision of the team schedule and ensuring that Amy meets the relevant milestones at the beginning of the schedule | Junior will be present during the initial interviews for the mobile application and content determination to ensure that he understands the content necessary. He will then need to continue with his sections of the project based on his own insights from the interviews. |
| Scope creep in the mobile application development due to the initial interviews and feedback from the early online surveys | Medium | High | Amy | Focus on the core features of the project. Add extra features after completion of core features | The Strictly Follow the project Gantt chart or timeline. Focus on the features that will be tested during the next evaluation | Rank the features according to their importance in the project and remove the features of lesser importance from the project schedule |
| Scope creep in the sentence planner and realizer | | | Junior | | | |
| Breakdown in communication between the team members causing issues with integration | Low | High | Team | Regular team meetings where members share their progress in their section of the project and voice difficulties | Ensure that difficulties and confusion from one meeting is resolved before the next meeting | An emergency team meeting is scheduled where each member shares their progress in the project. Difficulties and confusion are identified and resolved in the meeting. |
| The project exceeds the deadline due to delays in the mobile application and content determination intermediate evaluations, such as the online surveys | Medium | High | Amy | Create a timeframe for the intermediate evaluations to ensure that it does not hinder the project. If timeframes are unrealistic, then a readjustment of the schedule will be done | Ensure that milestones are met in the team schedule and that members have shown satisfactory progress in regular team meetings | Hand the project in late and discuss consequence with supervisors |

| | | | | | | |
|---|------|------|--------|---|--|--|
| The project exceeds the deadline due to delays caused by difficulties in the sentence planner and/or realiser | | | Junior | Follow an iterative approach when implementing features to ensure that problems are dealt with earlier in the project | | |
| Failure to receive ethics clearance | Low | High | Team | Apply for ethics clearance early and strictly follow the application guidelines | Keep track of submission deadline | Seek the guidance of supervisors on how to apply for clearance, and if ethics clearance is not accepted within the lifetime of the project a redesign of the evaluation plan is completed |
| Development of software components (i.e., NLG engine and Mobile Application) exceed projected time | High | High | Team | Continuous reassessment of the schedule is done each week in the project's lifetime to ensure that the relevant adjustments are made to accommodate underestimation of development time | Ensure that little to no milestones are missed in the project schedule | An emergency meeting is conducted with the team and supervisors where the team schedule is scrutinized and adjusted to accommodate for prolonged development. If adjustments cannot be made with the current workload, then the scope is reduced to more important features. |
| Unable to attract test subjects for evaluation | High | High | Team | Explore additional ways of attracting test participants and start recruiting as early as possible | Keep a record of test subjects interested in participating in study in advance | Explore other evaluation methods which do not require human participation. |
| Team member unable to complete their allocated workload | Low | High | Team | The work has been modularized to ensure that members can work independently | Regular team meetings to keep track of members progress and use online collaboration tools (such as Trello) to organize project work | Report progress regularly to the other team member and to the supervisor |

Appendix B: Gantt chart



