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Mobile-based application for discovering family relationship using rule based system in Tanzania

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NM-AIST

MOBILE-BASED APPLICATION FOR DISCOVERING FAMILY RELATIONSHIP USING RULE BASED SYSTEM IN TANZANIA

Aina Kipendaroho

A Project Report Submitted in Partial Fulfillment of the Requirements of the Award the Degree of Master of Science in Embedded and Mobile Systems of The Nelson Mandela African Institution of Science and Technology

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ABSTRACT

Family is a basic unit in society where traditionally, parents raise their children and family bonds survive longer and provide a primary sense of belonging. It has been observed that it become difficult when extended family become complex to find distant relatives using traditional approaches this is due to rural-urban migration and residential mobility, which has been weakened family relationship. Several researchers have developed systems to help relatives in discovering their family relationships using genealogical data, nevertheless, these systems may provide false-positive findings when there is lack of information. In Tanzania the genealogical sites have insufficient individual's family information for family discovery. The purpose of this paper is to present a developed mobile based application for discovering family relationships with no use of genealogical data and use of rule-based system to identify the type of relationship with a person. Both primary and secondary data collection methods were used to collect data and analyzed using R-studio. The research revealed that rule-based system can easily discover family relationships, and families grow when people interact with the mobile application (MyFam). The system was validated with users, where results emphasized its efficiency as a discovery tool with performance of 40% in user experience, 40% in system functionalities and 55% in system interface. The contribution of this study is to provide a mobile application that can be used in many countries for discovering family members relationships. In addition, due to efficacy of the rule-based system, any relationship can be inferred simply and reliably based on how family relationships are named.

DECLARATION

I, Aina Kipendaroho, do hereby declare to the Senate of The Nelson Mandela African Institution of Science and Technology that this project report is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by The Nelson Mandela African Institution of Science and Technology, a project report titled "***Mobile-based application for discovering family relationship using rule-based system in Tanzania"*** in partial fulfillment of the requirements for the degree of Master of Science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology.

Dr. Neema Mduma	Mduma	09-08-2022
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DEDICATION

With thankful heart, I dedicate this project work to my husband Abiudi Alfredi and my lovely son Alfred-Junior for their consistently support in accomplishing my Master's degree.

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AI	Artificial Intelligence
CLIPS	C language Intergrated Production system
GPS	Global Positioning System
PBBA	Parental Bidirectional breadth Algorthim
REP	Requirement Engineering Process
SL5	SNOBOL 5
SMS	Short Message Service

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

The family has been regarded as the bedrock of society, sometimes referred to as the bastion of social cohesion (Schiefer & VanDerNoll, 2017). In Tanzania, the most common family structure is an extended family, in which children are raised by their parents with the assistance of close relatives and neighbors (Mathias & Daniel, 2018). It has been heightened by including some of the benefits, such as supporting one another, protecting additional family members from undesirable social conditions, such as disease, and providing economic assistance to one another (Affandi & Habibah, 2017). Traditionally, parents or elders introduce family relationships between people of different generations. By being introduced by their parents, one can discover relationships with relatives such as uncles, aunts, nieces, cousins, and so on. Relationships within the family last longer, where people are more cherished and usually have a stronger sense of belonging compared to other institutions (Armstrong, 2013). Individuals are tied to one another by powerful, durable, multigenerational emotional attachments and loyalties (Hornstra *et al.,* 2020).

According to Walsh (2015), family members have become disconnected from one another and have missed out on important life relationships that could have improved family cohesion due to the complexity of relationships that are growing in family structures as well as social and environmental changes such as geographical proximity. However, to maintain family solidarity and cohesion, technological advances are argued to be positive elements in improving the discovery of family relationships (Taipale, 2019).

In recent years, the advent of artificial intelligence (AI) has led to the implementation of human-engineered systems that exhibit intelligent behaviour or characteristics (Adewale *et al.,* 2018). According to Agwu *et al.* (2018) artificial intelligence is also characterized as a tool for understanding the relationships between complicated phenomena. One prominent artificial intelligence technology is the rule-based system, which transfers the knowledge of human experts with vast task-specific expertise to a computer. The information will be stored on the computer, where rules will be extracted from user inputs and the computer will be able to make inferences and result in a certain conclusion (Isinkaye *et al.,* 2017).

Apparently, a number of expert system tools have been used to discover people's family relationships based on personnel history and to develop a visualization of family trees to represent family information that allows users to enter their genealogical information and run a search algorithm that matches family members based on meta-data and genealogical tree relationships, which helps in the discovery of historical information by tracking the ancestors (people before you) and help people to discover family information such as household structure, family size, and so on (Peng *et al.,* 2020).

Advances in mobile technology have also motivated researchers to focus on developing mobile systems that can improve stand-alone interactive family discovery systems and make them more accessible, especially in developing countries (Pasha *et al.,* 2020). Furthermore, mobile technology has enhanced ubiquitous interaction among non-coresident family members (Taipale, 2019) also introduced the concept of "digital families" as a type of distributed extended family comprised of related individuals living in one or more households who use at least a basic level of information and communication technologies and social media applications to stay connected and maintain a sense of unity. The objective of this study was to develop a mobile-based application for discovering family relationship using rule-based system.

1.2 Statement of the Problem

Due to the sheer and extensive growth of the family structure, it is difficult for individuals to discover their distant family members; instead, people can only easily identify relationships within their immediate family members (Yar & Tun, 2016b). Geographic mobility is a major factor that inhibits interactions between non-coresident family members (Yar & Tun, 2016a).

However, there are several tools available to discover family members through online search with genealogical information systems that are based on pre-defined relationships by the user (Efremova & Calders, 2015). Genealogical data comprises a vast quantity of family information, genealogical tree relationships, and facial similarities, which provide an interface for searching and exploring historical family data. The false-positive match of the family relationship is likely to occur when there is incomplete metadata information and little genealogical information (Chu, 2017).

Nevertheless, in the local context, genealogical searches are ineffective since there are no historical information records which make most people when one conducts a genealogical

online search, it is difficult to discover their family information due to missing information in the cloud databases or the result may be provided with false-positive match.

Thus, the purpose of the project was to develop an integrated and interactive mobile-based system that will map the family information pattern based on the primary number of people provided by the user, with the family tree expanding as more users identify other people fit the same pattern. The system will utilize rule-based system to identify name or type of relationship. The system interface is user-friendly and effective, and allowing quick user adoption.

1.3 Rationale of the Study

The advent of the smartphone has profoundly changed the way information is obtained and people interact with one another, with significant ramifications for behaviour, culture, and society as a whole (Sbarra *et al.,* 2019). In 1993, the first smartphone was launched, and the number of smartphones continued to grow until 2015, when half of the world's population was using smartphones. The industry has been growing steadily, providing a total of almost 80% of the world's population in 2020 (Hübler & Hartje, 2016). According to Joseph *et al.* (2020) the number of smartphone users in Tanzania increased by 49% in the year 2020, with the growth of time spent using the devices.

Within a single device, the smartphone contains a diverse variety of technological capabilities. It may fulfil multiple needs at the same time, such as making a phone call, taking a photo, paying a bill, listening to music, watching videos, accessing the Internet, chatting on social networks, and generally being entertained (Derks *et al.,* 2016). All of the functionalities included within a smartphone have prompted the technology to be more intrusive than any other, and its ubiquitous use has improved how individuals maintain their interpersonal relationships (Cho, 2015).

Moreover, people all over the world communicate using new techniques of communication, such as social media networks and online videos, which makes it possible for even non-residents to be more engaging and communicative with their family members (Carvalho *et al.,* 2015). In contrast to the traditional method of face-to-face introduction with the elderly or parents, current communication methods allow people with complex family relationships to be discovered more quickly and easily (Sharaievska & Stodolska, 2017). Thus, the purpose of this study was to develop a mobile-based based application for family discovery using a rule-based system to improve family cohesion.

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1.4 Objectives of the Study

1.4.1 General Objective

Main objective of this project is to develop a mobile-based application for discovering family relationship using rule-based system.

1.4.2 Specific Objectives

(i) To identify requirements for developing a mobile-based application (MyFam App) for discovering family relationship.

(ii) To develop rules for discovering family relationships using rule-based system.

(iii) To develop a mobile based application for discovering family relationship

(iv) To validate the developed system.

1.5 Research Questions

(i) What are the requirements for developing a mobile-based application for discovering family relationship?

(ii) How to develop a mobile based application for discovering family relationship?

(iii) How to develop rules for discovering family relationships using production system?

(iv) How to validate the developed system?

1.6 Significance of the Study

The system is intended to enhance social interaction at the family level, where complex patterns of family relationships can be easily discovered. With its user-friendly interface, the system is

accessible to even the most novice user, and it allows them to accurately discover their family members and their relations. Furthermore, the system will allow users to enter their person information together with at least other two related family members so as to discover other relationships.

While several studies have been conducted in rule-based system relative few studies have focused on family discovery. In previous studies, none developed a mobile based system for family discovery which can be applicable for countries with no genealogical information data. The developed system "MyFam application" can be suitable for family discovery even with no genealogical information system.

1.7 Delineation of the Study

This work aimed at developing mobile based application for family discovery. The rules were developed using rule-based system to identify name and type of relationship which were integrated with the mobile application. MyFam mobile application designed as a social platform where people from the same kin can meet and interact. Results show that developed tool can accurately determine one's relationship after a user on the other side accept or confirm the relationship request.

However, it is worth mentioning that this study has some limitations. The rules applied solely to a common form of extended family and did not take into account other traditional cultures. Additionally, for user with no smart phone (use normal phones) can only accept or reject relationships; they cannot see or interact with their family members without having MyFam App.

CHAPTER TWO

LITERATURE REVIEW

2.1 Family Context

Family is the most common form of social organization (Haralambos *et al.,* 2004). It can be defined as the universal social institution which is a basic unit in society and has significant impact on the lives of individuals from birth until death (Finch, 2007). Family can also described as a close domestic group of individuals who are connected to one another by blood, social mating, or legal connections (DeVito, 2007). A common type of family in many countries is one based on the nature of relations among people who have a blood relation or are consanguineal kin, i.e., a family consists of parent(s) and children or siblings (brothers and sisters) (Mondal, 2014).

2.2 Family Structure

There are number of family structure, but commonly are : nucleus family (immediate family) and extended family (distant family) (Zahran, 2011). The nuclear family consists of two generations, wife/mother, husband/father and their children as shown in Fig. 1.

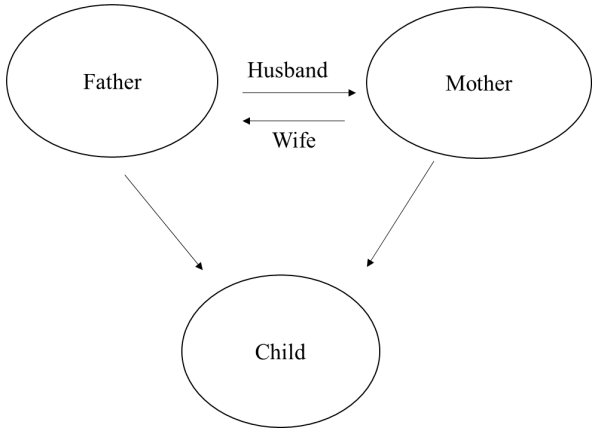

Figure 1: Family structure

While, extended family consists of at least three generations; grandparents on both sides, the wife/mother and husband /father and their children together with the parallel stream of the kin of the wife and husband (Georgas, 2003). With expansion of family structure which become more complex as the increase of descendant level (generation level) and horizontal expansion of family members as demonstrated in Fig. 2.

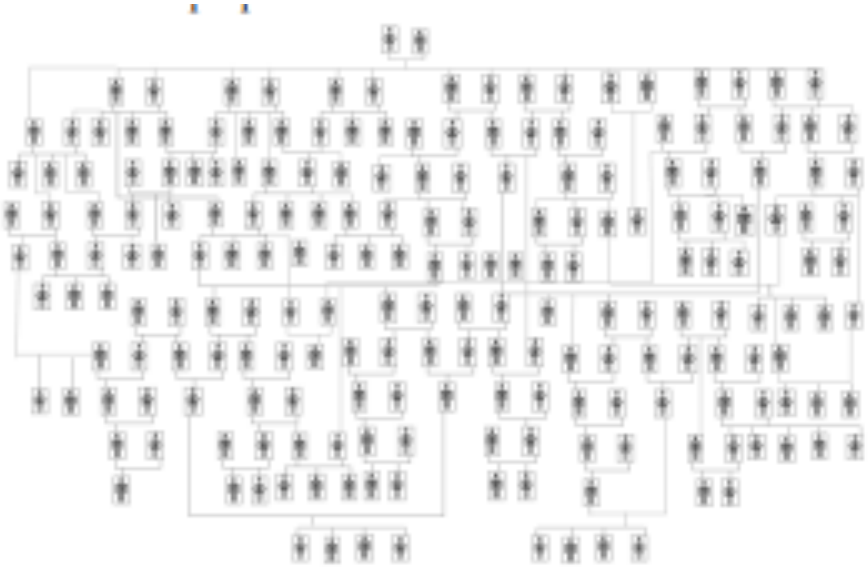

Figure 2: Complex Family structure

Depending on the culture, there are several forms of extended families around the world. The most common sort of extended family is the polygynous family, which consists of one husband/wife and two or more wives/mothers, with a maximum of four wives according to Islam religion, together with their children and kin (Nakane, 2019). However, the actual number of polygamous families is very small.

In Tanzania, the most common family structure is an extended family, in which children are raised by their parents with the assistance of close relatives and neighbors (Mathias, 2018) as shown in Fig. 3.

Figure 3: Family Relationship in Tanzania (Ndhlovu, 2017)

Despite the common name that are used for a certain relationship, In Tanzania there are other local names that are used; however, they are of the same meaning. For example: "**Mother**" in Swahili means "**mama**", but other name in native Swahili is known as "**nina**''. Table 1 below adapted from Gafkosoft (2020) is the list of family relationship with the native Swahili names that people use.

Table 1: Relationship names and their meaning in Swahili and English (Gafkosoft, 2020)

Names (In English)	**Majina (In Swahili)**	**Another name (In Swahili)**	**Relationship (In Swahili)**	**Relationship (In English)**
Father	Baba	-	Mzazi wa kiume	Male parent
Mother	Mama	Nina	Mzazi wa kike	Female parent
Son	Bin	Mwana	Mtoto wa kiume	Male's child
Daughter	Binti	Mwana	Mtoto wa kike	Female's child
Wife	Mke	-	Mwanamke mliyefunga ndoa pamoja kuanzisha familia	A married woman considered in relation to her spouse
Husband	Mume	-	Mwanamume mliyefunga ndoa pamoja ili kuanzisha familia	A married man considered in relation to her spouse
Step-mother	Mama wa kambo	-	Mama asiyekuzaa aliyeolewa na baba yako	A woman who is the wife or partner of one's father
Step-Father	Baba wa Kambo	-	Baba asiyekuzaa aliyemuoa mama yako	A man who is the husband or partner of one's mother

Names (In English)	Majina (In Swahili)	Another name (In Swahili)	Relationship (In Swahili)	Relationship (In English)
Grand Father	Babu		Baba wa baba yako /mama yako	The father of one's father or mother.
Grand-Mother	Bibi	Nyanya	Mama wa baba yako/mama yako	The mother of one's father or mother.
Great Grandfather	Baba mkuu	-	Baba wa babu	The father of one's grandmother or grandfather
Great-Grandmother	Nyanya mkuu	-	Mama wa bibi	The mother of one's grandmother or grandfather
Uncle	Mjomba	Hau	Kaka wa mama yako	The brother of one's mother
Uncle	Baba Mdogo		Mdogo wa kiume wa baba yako	The brother of one's father
Uncle	Baba Mkubwa	Ami/amu	Kaka mkubwa wa baba yako	The brother of one's father
Aunt	Shangazi	Mbiomba/ amati	Dada wa baba yako	The sister of one's father or the wife of one's uncle
Nephew, niece	Mpwa		Mtoto wa ndugu yako	Nephew - a son of one's brother or sister, or of one's brother-in-law or sister-in-law. Niece - a daughter of one's brother or sister, or of one's brother-in-law or sister-in-law.

Names (In English)	Majina (In Swahili)	Another name (In Swahili)	Relationship (In Swahili)	Relationship (In English)
Cousin	Binamu		Mtoto wa mjomba wako (ke au me)	A child of one's uncle or aunt.
Cousin	Binamu	bintiamu	Mtoto wa kike wa mjomba wako	A daughter of one's uncle or aunt.
Brother-in-law	Shemeji	-	Ndugu wa kiume wa mume wako Mume wa dada yako (kama ni me)	A brother of one's husband or wife.
Sister-in-law	Wifi/shemeji	-	Ndugu wa kike wa mume wako (wifi) Mke wa kaka yako (shemeji)	A sister of one's husband or wife.
Father-in-law	Baba mkwe	Bavyaa mcheja	Baba wa mke wako au mume wako	A father of one's spouse
Mother-in-law	Mama mkwe	Mavyaa mcheja	Mama wa mke/mume wako	A mother of one's husband or wife
Aunt-in-law	Mkaza mjomba	Mkaza hau	Mke wa mjomba wako	A wife of one's uncle
Daughter-in-law	Mkaza	Mkaza mwana Mka mwana	Mke wa mtoto wako	A wife of one's son

2.3 Visualization of Family Relationship

Representation of family members can be in hierarchy form to show their relationship based on gender and age. Relationship is to be presented in descendants order showing one's ancestors (level of generations). The common form of visualizing family structure with the relationship is by using family tree (pedigree charts). Family tree (Genealogy) is the chart that represents family relationships in a convention tree structure. It indicates how close to distant members of family are related (Cati, 2020).

2.4 Rule-based System

Artificial intelligence researchers were the first to design rule-based systems were the knowledge of an expert needed to run in inference engine. Several studies have proven, in particular, that reasoning alone is not a sufficient measure of intelligent behaviour; rather, one must have a diverse set of knowledge to reason (Nishant *et al.,* 2020). It was also recognized that the problem needed to be narrowly targeted, with only relevant knowledge applied. Expert systems were given this name because of the nature of these intelligent computer programs (Isinkaye *et al.,* 2017).

An expert system is a branch of computer programs that transfer the intelligent (knowledge) of human experts into machines (computers). The knowledge is then stored in the computer and users call upon the computer for a specific advice as needed (Chen & Rada, 2019). Computer can make inference and arrive to a certain conclusion.

Expert system provides a powerful and flexible means to obtain solutions to a variety of problems that often cannot be dealt with by other (Walek & Spackova, 2018). The system can explain "why" to various questions that are being asked, and "how" a given was obtained (Isinkaye *et al.,* 2017). One of the principal attractions of expert system is that they enable computers to assist humans in many fields, these systems are known as rule-based system (Nishant *et al.,* 2020).

Rule-based system is defined as one, which contains information from human expert, and represent that information in the form of rules such as IF-THEN. The rules can be used to perform operations on data to inference in order to reach appropriate conclusion (Masri *et al.,* 2019). These inferences are essentially a computer program that provides a methodology for reasoning about information in the rule base (Almadhoun & Abu-Naser, 2020).

Rule-based systems can be applied on: knowledge base maintenance (Alkahlout *et al.,* 2021), communication system fault diagnosis (Martín *et al.,* 2012), material processing designs (Pao & Lin, 2012), probabilistic fault diagnosis, system development (Venkatasubramanian *et al.,* 2003), genealogical information (Yar & Tun, 2016b), tutoring system (Hatzilygeroudis & Prentzas, 2015) and so forth.

Rule-based systems tool or shell is a software system that contains basic components which are knowledge base, inference (reasoning) engine and user interface as presented in Fig. 4.

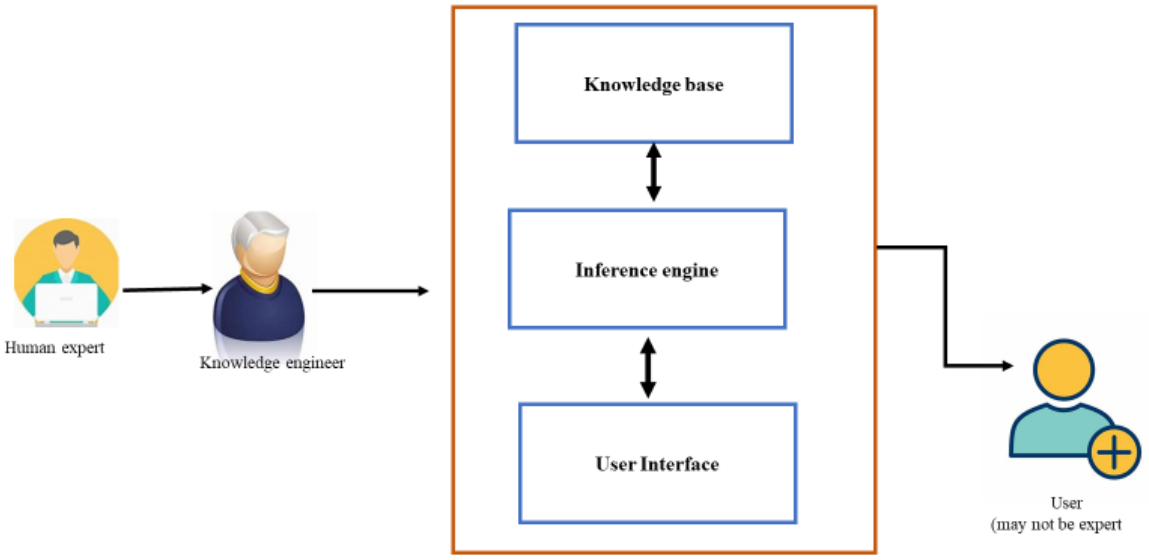

Figure 4: Rule base architecture

2.4.1 Knowledge Base

The knowledge base comprises of the information needed to understand, formulate and solve problems. It is made up of facts and rules about a specific issue that are comparable to those of a human expert (Al Ahmar, 2010). It includes both factual and heuristic information. Factual information is knowledge that is widely disseminated, such as that found in textbooks or journals. Heuristic knowledge is less rigorous, more experienced, more judgmental, and rarely debated than scientific knowledge (Masri *et al.,* 2019).

There are different knowledge-representation techniques to be used to provide a general structure of relationships which can be represented with descendant order (number of generation) or horizontal relationship.

Figure 5 shows the descendant relationship of grandparents, parents and children with different level of generation. Mothers represented by M1 and M2, Fathers represented by F1 and F2, CM1 represents child of the mother 1 (M1), CF1 represents child of father 1 (F1) and C represents Child or Children.

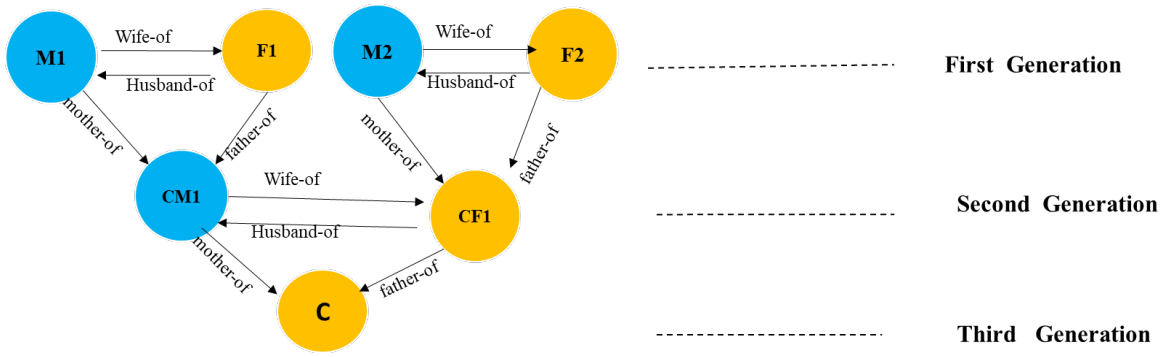

Figure 5: Descendant relationship structure

Figure 6 shows the horizontal relationship where each generation can have. The horizontal relationship can be complex as was shown in Fig. 2 which can be difficult for a certain person on first generation to easily know the type of relationship, he/she has with someone in the third generation. Mothers represented by M1 and M2, Fathers represented by F1 and F2, CM1 represents child of the mother 1 (M1), CF1 represents child of father 1 (F1), Brothers and Sisters represented respectively by B and S.

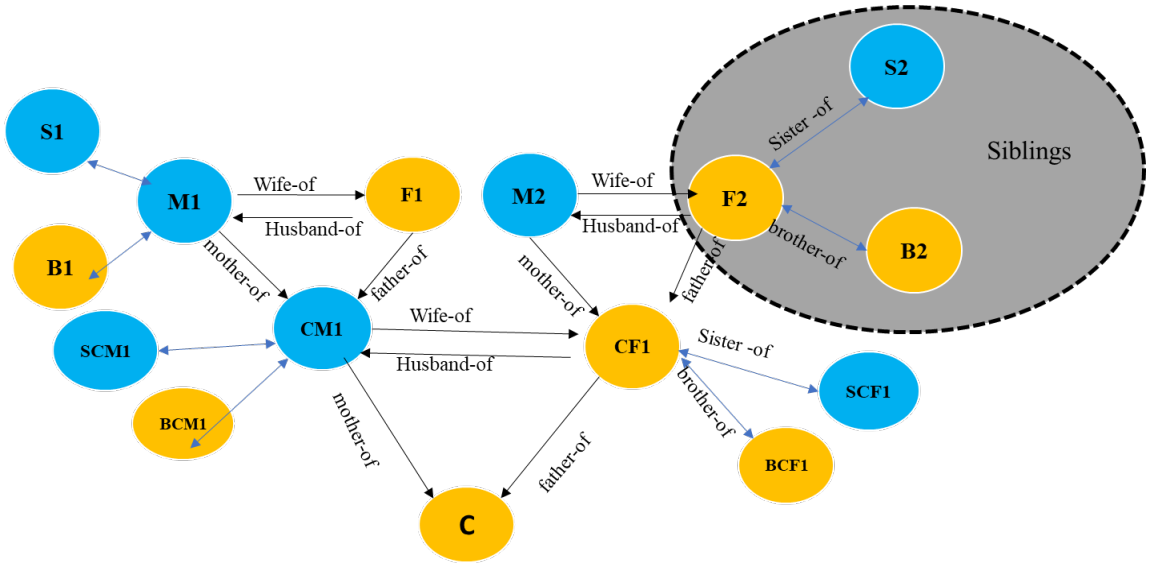

Figure 6: Horizontal relationship structure

2.4.2 Inference Engine

Inference engine is the brain of a knowledge-based system. It uses the control structure and provide methodology for reasoning. It performs the task of matching antecedents from the responses given by the users and firing rules (Martín *et al.,* 2012). A rule consists of two parts: condition (antecedent) which contains "IF" statement that describe facts and conditions that must exist for the rule to fire and conclusion (action, consequent) which contain "THEN" statement, describe the facts that will established or the action that will be taken or conclusion that will be made (Isinkaye *et al.,* 2017).

There are two inference engine strategies which are; forward chaining and backward chaining. Forward chaining (data driven) is a strategy that can answer the question; "what can happen next?". It follows the chain condition, derivation and finally deduce the outcome (Fig. 7). It considers all the facts and rules and try to sorts them before concluding to a solution (Kamley *et al.,* 2016).

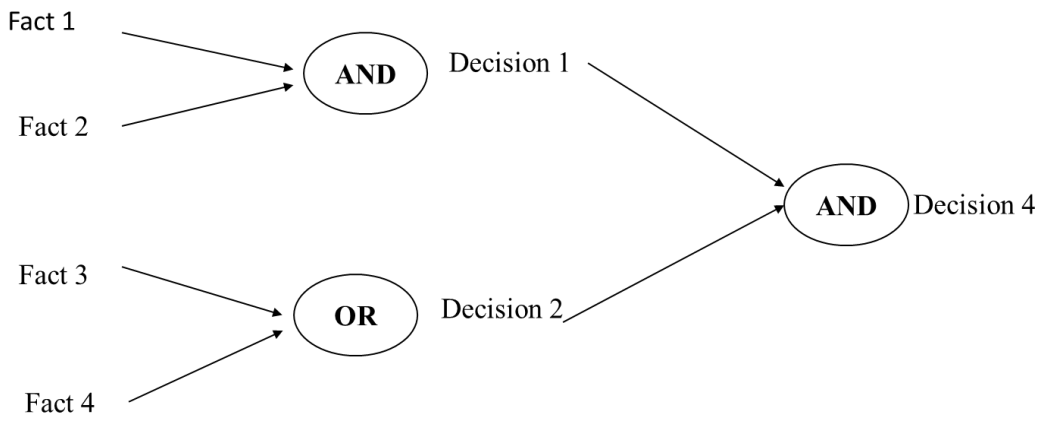

Figure 7: Forward chaining strategy

Backward chaining (goal driven) is a strategy that can answer the question "why this happen?". It begins with a question to be answered and searches for rules that will assist in resolving it. Backward chaining also means reasoning from *goals* back to *facts* (Nowak-Brzezińska & Wakulicz-Deja, 2019).

2.4.3 User Interface

It is a means of communication with user. It provides facilities such graphical user interfaces so as to convert rules from knowledge representation which user may not be familiar to the user understandable form (Kamley *et al.,* 2016).

2.5 Related Works

Rule-based systems provide a powerful and versatile approach of obtaining solutions to a wide range of issues that are frequently intractable using other, more traditional methods. As a result, the application is spreading to many areas of social and technological life and proving to be crucial in the decision-making and problem-solving processes.

Recently, Peng *et al.* (2020) developed a genealogy data service platform for kinship for efficiency and reliable data input digitization of genealogies, diversified genealogy visualization and valuable genealogy data analysis to end users. The system is more applicable on historical or humanities research. However, more language models are required to process genealogy data and there is mixture of information from various field, which makes potential use of genealogy data not to be completely efficient.

Furthermore, Nuanmeesri *et al.* (2010) developed a system to search for genealogical information in a family tree by using Parent Bidirectional breadth Algorithm (PBBA) and identify relationship and name by applying a rule-based system with English rules. The study focused on solving a problem such as moving of daughters to their husband's house because of marriage and to know the consanguine relationship of two people who do not live in the same house. However, the system was able to find a connection between only two nodes (people and parent) and not a consanguine relationship of the group of people.

Similarly, Borges (2019) proposed a new family tree visualization design that is focuses in providing contextual information about a root couple and their ancestors so as to compare the age between spouses, analyse the size of nuclear family, and ability to produce visualizations from information that was already collected and organized by genealogists. Despite the success of the proposed system, it was reported to have limited interaction for easily exploration of data.

Moreover, Fu *et al.* (2017) developed an interactive visual analytic system for a very large real-world data set that compares the connection of ancestral features and family tree topologies across generations with a steep learning curve. The system leverages a dynamic visualization to organize and demonstrate a massive collection of family trees by growth and continuity, and it provides full information about each family tree on the Sankey nodes. However, a huge number of trees can be compared at the same time, but the technique does not scale well when some of the trees have a significant number of generations. Furthermore, for the system to be

used and adapted effectively, a massive dataset containing large-scale household and individual-level data covering the entire population is required.

In addition to that, Yar and Tun (2016b) developed a system for searching relationships based on personal information of separated nodes stored in a graph database. Prolog a declarative programming language in a rule-based system expressed in terms of relation, and represented as facts and rules. In this system, person names are only considered for search keywords. However, sometimes the inputs person names may be the same, the system may consider the relationship is cyclic and/or have the same common or intermediate person which might make a false-positive match. Moreover, the system was implemented on the platform of a homogeneous database that makes the time complexity of algorithms not to be considered.

Siqueira *et al.* (2016) presented family tree visualization using a conical-shaped family tree layout to properly display all necessary and useful information. The study proposed searching connections among persons in social networks and family trees by using graph traversal algorithms through predefined relationships among them by using personal relationship algorithm and personal deduction algorithm. However, as a family gets bigger, visualizing it becomes a more difficult task, and the system is not interactive.

Also, Boonnavasin and Rattanatamrong (2016) designed a web-based JavaScript library "enGeno" to facilitate on implementing genogram related functionalities for physicians to understand patients' family information. The functions support genogram creation, visualization, edition, search, filtering, export and import which enhance the effective diagnosis of the physicians. The study presented an open-source JavaScript library based on GoJs framework to create and manipulate medical monograms and argue the library to be integrated in a web and mobile applications.

Maríк (2016) proposed a method to represent large family trees. The study argued that traditional methods are adequate when the focus of the analysis is centered on the key individual. Expert system technology was applied in genealogy search using CLIPS library so as to help individual to trace their members history and find relatives. The proposed method is adequate for the high-level study of family relationships, but it has only focused on the ancestor's history cannot discover people after your birth (the next generation) and siblings.

Furthermore, Ball (2017) proposed a family centric tree-like visualization that shows when people lived in relation to other people. The visualization represents family units and their

members, enabling a clear identification of which family an individual came from and of the time when his family live. However, the system is not scalable for very large families.

Mukaliyev (2015) proposed an interactive method based on a dual-tree scheme. The dual-schemes aims at arranging tree nodes automatically in a way that avoids edge crossing and maintains a clear presentation of the relations between family members. Also, method includes temporal information about the lives of individuals by means of lifelines in the form of individual age and the moment when he or she lived. According to the author, the method has limitations when dealing with duplicated occurrences of individuals and missing data.

The systems mentioned above demonstrate various methods for discovering family relationships. Existing systems for family discovery are mostly focused on the extraction of family information from genealogical data, which is likewise primarily focused on ancestor information. The majority of systems generate static family trees that are not interactive. The existing systems are incompatible with the local context, particularly in Tanzania, where different types of family relationship names are employed. Therefore, to overcome the limitations of the existing systems, the objective of this study is to develop a mobile-based application for family discovery that uses a rule-based system. The system is meant to be useful in the local context, with a user-friendly interface that adapts well to the user.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area and Scope of the Study

Dar es salaam is the largest city one of Tanzania's fastest growing cities, with a high rate of migration driving its expansion (Peter & Yang, 2019). Due to rural-urban migration and residential mobility, Dar es salaam population is expected to reach mega city status by 2030 (Todd *et al.,* 2019). It has been observed that some migrants suffer from such shifts, including weakened family relationships (Omunga, 2020). Dar es salaam city comprises of five cities Ubungo, Kinondoni, Kigamboni and Ilala and Temeke. The study was carried in Goba ward in Ubungo district whereby according to the 2012 population census, the municipality had the population of 845 368 and the projection of 2016 has the total population of 1 031 349 with the growth rate of 5% per annum (Statistics, 2012).

3.2 Research Methods

This research employed both qualitative and quantitative research methods. Qualitative research methodologies were employed to comprehend concepts and experiences, as well as to gain in-depth insights into concepts that were not well understood. The qualitative approaches used was to review previously published works by other authors. Quantitative methods were employed to establish generalizable facts about a study. Also, system development methods such Agile approach was used to provide structure, plan and to control process during development.

3.3 Target Population

The target audience consisted of smartphone users between the ages of 18 and 45 who are permanently residing in Goba, Dar es Salaam but whose origin is from another region (for example, a person born in Mwanza but now resides in Dar es Salaam) and whose relatives are largely residing in that other region (outside Dar es salaam). It has been reported that 67% migrate from their original lands to economic cities such as Dar es Salaam, with the bulk of them being permanent migrants (Nations, 2018). It normally takes years for them to communicate with their other distant relatives, so their children only know their immediate family members.

3.4 Sample Size and Sampling Technique

During the study, total population in Goba ward were approximately 15 765 people, since the target age of the study was between 18-45 the target population found to be approximately 7490 also study assumed from the 67% are people who are migrants in Dar es salaam which make the total of the target population to be 5018. Since the study could not obtain the exactly number Android users in Goba ward, the study made the assumptions based on global mobile market where android users cover 70% of the global market thus make the target population to be approximately 3512.

A sample size of 97 participants was selected based on the Yamen formula which based on 3512 target population at the precision of 10%, therefore the sample size was 97 people. Yamen formula is one of calculation formulas to determine optimum sample size for both continuous and categorical variable at all level of confidence (Adam, 2020) .

Below is the mathematical illustration for the Taro Yamane method to determine a sample size of a given population.

$$n = \frac{\mathrm{N}}{1+ \mathrm{N}(\mathrm{e})^2} \quad (1)$$

n = sample size

N= population under study

e = margin error (10%)

From the given population:

n = 3512/ (1+ 3512(0.01))

n = 97

Convenience and snowball non-probability technique was used to reach 97 participants based on the availability and willingness to participate in the study.

3.5 Data Collection Methods

The data collection methods were classified into two categories: Secondary data and Primary data.

3.5.1 Secondary Data Collection

Secondary data were acquired from existing study papers such as journal articles, reports, genealogical information websites, and databases. These data, which had already been obtained and compiled for analysis, were reviewed in order to get a better understanding about the concept of family and its significance in both the global and local contexts. The document also aided in identifying gaps between existing systems.

3.5.2 Primary Data Collection

Primary data were collected using online survey with close-ended questionnaires.

Online survey questionnaire: The questionnaire with list of closed questions was distributed online and in person to gather diverse information. The questionnaire was sent to target respondents via email and social media platforms and text message.

3.6 Data Analysis

The data collected was retrieved from the Google form and saved in CSV format. All of the data collected was coded and analyzed in R studio. R studio is an integrated development environment (IDE) for the R programming language. R is a statistical analysis and graphics programming language (Brittain *et al.,* 2018). Because of its versatility and rich statistical language, R studio was the best choice. R Studio can also be used in conjunction with other tools such as Microsoft Excel, MATLAB, Statistica, SPSS, and SAS (Maddumage & Dhanushika, 2018). After cleaning and processing the data with R tools, descriptive analysis was used to summarize the data so that it was more legible and understandable. The descriptive analysis method is popular because it provides a fuller picture of an event, allows for data distribution interpretation, and identifies similarities across variables. It aided in the development of clear requirements for designing and building the prototype based on user preferences in this study, as well as in justifying the existence of the problem.

3.7 System Development Approach

The system was developed using agile approach. Agile is an iterative approach which is known as adaptive software development methods where tasks are divided into small time frames to deliver specific features for a release (Campanelli & Parreiras, 2015),unlike traditional SDLC (Waterfall methodology) which focuses on contracts, plans, documents and tools(Chari &

Agrawal, 2018). Agile is an adaptive method where there is no detailed planning and there is clarity on the future tasks only in respect of what features need to be developed (Mohammad & Alwada'n, 2013) (Fig. 8).

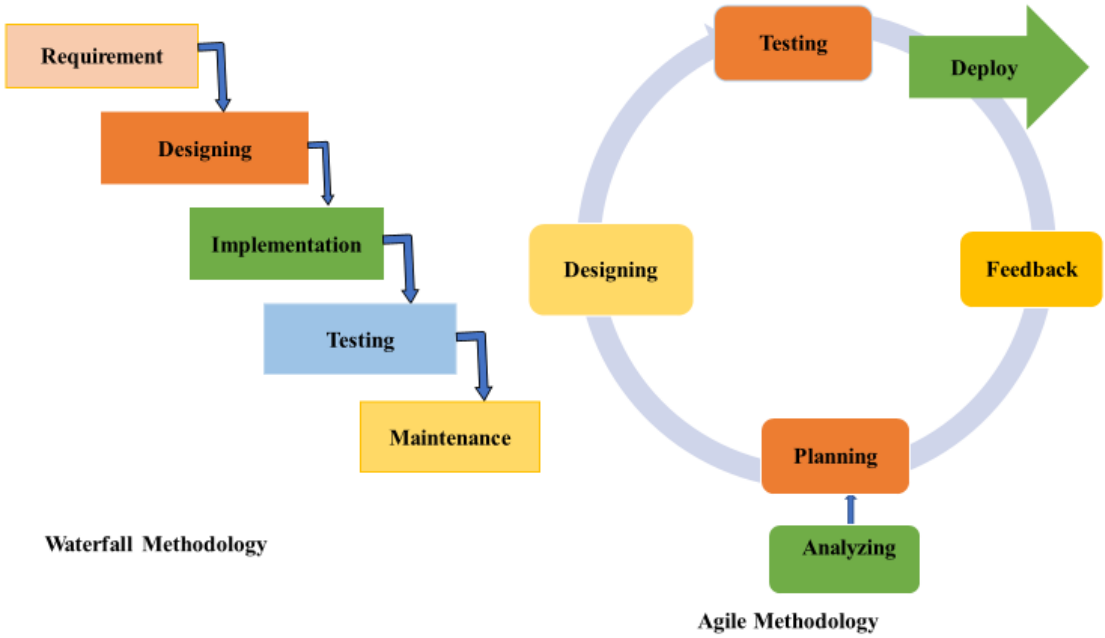

Figure 8: Waterfall vs Agile methodology

3.8 System Development

3.8.1 Functional and Non-functional Requirements

Functional requirements describe the expected behaviour of the developed system in terms of tasks to be performed by the system. In this developed system, functional requirements were categorized according to graphical user interface, user authentication, new relation discovery, and relationship request. Non-functional requirements are not concerned with the system's fundamental functions or what the program should do, but rather with quality and how the system should perform in order to satisfy the end user (Mujawar *et al.,* 2020). In this developed system we focused on portability of the system, security, maintainability. Flexibility, scalability, performance and reliability. The functional and non-functional requirements are described in Chapter 4.

3.8.2 System Design

After the gathering and analysis of system requirement, consequently the conceptual design was developed. The proposed system describes the design concept and component show interaction with one another within a system. the system design involved mapping core functionalities to different system actors and depicting system processes. The system design is explained in chapter 4.

3.8.3 Tools and Materials

(i) Software Requirement

In this study system requirement were include software requirement for rule-based system and software requirement for mobile development.

(a) Prolog Rule

Prolog rules it is declarative programming language in which program statements describe the facts and rules of various problems within a formal logic framework. It is suitable for programs that involves non-numeric computation, where symbol and inference manipulation are the fundamental tasks (Nerode & Shore, 2012).The rules are stated in the form of logical clauses with a head and a body. For example, H represents the head, whereas B1, B2, and B3 represent body parts. This is a rule if we say, "H is true when B1, B2, and B3 are all true." Facts, on the other hand, are like rules but without a body. So, "H is true" is an example of a fact. In this study the prolog rule was used to identify the relationship name between two people which depends on the one's level of generation and kind of sex (Hsu & Lin, 2020).

(b) Android Studio

Android studio is a free open-source software which contains features that simplify the coding process while developing application. Android studio was useful editor due to Gradle integration, advance in Java code auto-completion, system stability and project workflow (Syaifudin *et al.,* 2021) as presented in Appendix 2.

(c) Java

Java is one of the leading languages of computer programming which is class based, concurrent, object oriented and extremely designed for avoiding dependencies related to

implementation (Abdallah & Al-Rifaee, 2017).It ensures software development since it is always quick, safe, portable, stable, and capable of doing a wide range of activities at the same time, among other characteristics (Gusarovs, 2018). Due to the fact that Java is integrated into the Android Studio IDE and provides syntactical and library support, it was chosen for this research project.

(d) SQLite Database

SQLite is a C library that contains a relational database management system (RDBMS). SQLite is commonly known for its ability to be embedded in end-user programs (Obradovic *et al.,* 2019). SQLite is intended to be used with structured data presented in a relational model, that is stored locally on Android devices and is attached to the application to operate within the logical design of the host application (Musleh *et al.,* 2018). With almost no configuration, it supports transactional features and cloud platform operations. Unlike any other SQL database, it is an embedded SQL Database engine with no separate server process (Kornaś, 2021).

SQLite was chosen for this study because it can be saved on disk or in memory, and each database is kept in a single disk file that can be used on multiple platforms. It is extremely fast and requires very little memory to function (Musleh *et al.,* 2018). SQLite, unlike other database engines, supports toolchain and is included in the android development environment (Haldar, 2016). It is very customizable, allowing programmers to design their desired structure. SQLite provides data that can be debugged by leveraging existing SQL (Korna, 2021).

(ii) Hardware Requirements

The system was designed with Android (mobile) operating system which is the most prevalent and commonly used mobile operating system in Tanzania and Africa as of now (Alexander *et al.,* 2021). Android smartphones take up almost 60% of user compared to Apple devices this is because of its broad price range and lower entry level price point which makes high largest share in developing countries (Haris *et al.,* 2018).

The implementation was also designed to be suited for user with no smartphone where they can use their small phones to confirm family discovery request.

3.8.4 System Implementation

Through requirement gathering and system design processes guided the choice of tools to be used to implement the solution, various tools were used based on their reliability, cost and availability.

(i) Development of Android Mobile Application

With the help of Integrated Development Environment (IDE) using Android studio, MyFam application was developed using Java Programming Language.

(ii) Development of Rule-based System

Prolog rule was used for the development of inference engine that runs in background to match user relationship information. The family relationship was presented in a family tree, which mapped into facts and rules using Prolog rules as shown in Fig. 9.

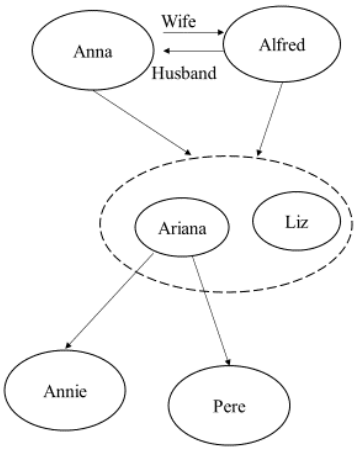

Figure 9: Family relationship tree

Ariana is a child of Anna and Alfred, Ariana has also two children and Ariana is a sister of Liz, whose parent are also Anna and Alfred.

Predicates:
Parent (Anna, Ariana)
Parent (Alfred, Ariana)
Parent (Alfred, Annie)
Basing on the elements of prolog rules

Facts: Ariana is a daughter of Alfred

Some additional facts were also defined un the system

Sex of family members was defining as:

Female (Anna)

Male (Alfred)

Female (Ariana)

Female (Annie)

Rules: Grandfather (Alfred, Annie), father (Alfred, Ariana) parent (Ariana, Annie) implies that for Alfred to be grandfather of Annie; Ariana should be parent of Annie and should be mother of Ariana.

Some additional rules were also added as shown in Fig. 10.

i.e., defining relationship of mother and sister

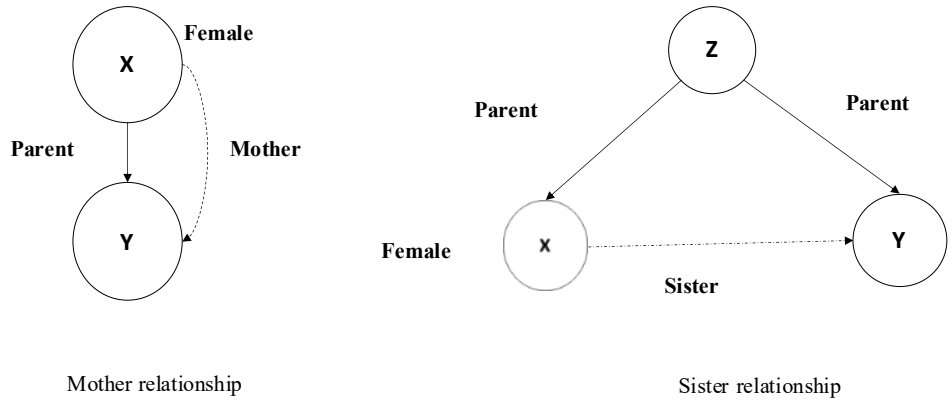

Figure 10: Mother and sister relationship

In Prolog the statement declared as; -

Mother (X, Y): - parent (X.Y), female (X).

Which means X will be the mother of Y, parent X is Female

Sister (X, Y): -parent (Z, X), parent (Z, Y) Female (X), X\==Y.

which means X will be the sister of Y if they both have same parent and X is female and X is not equal to Y (age)

Questions: To run a program, questions need to be asked that can be answered by facts and rules. Which were declared in Prolog console.

3.8.5 System Testing

The system testing is important to ensure that all the developed system met the requirements. The V-Model was adopted to test the proposed system. The V-Model comprises of the following stages: Unit testing, Integration testing, system testing and User acceptance testing

(i) Unit Testing

The unit test was carried out to ensure the correctness of individual interfaces and integration of multiple modules. This includes fast loading speed where it takes 2s for screen loading, push notifications using text send to user for authentications and request notifications.

(ii) Integration Testing

The integration test was carried out by testing how rule-based system interacts with the MyFam App by automatically discovery new relationship.

(iii) System Testing

The overall system was tested to ensure that it met the design standards. When a user requests a relationship, notifications should be sent to the other user and show the name of the relationship to show how two people relate. For example, if Annie is Pere's sister and sends a request to Pere, Pere should receive notifications to confirm, and once a user (Pere) accepts, a user (Annie) should receive notifications and the relationship should be added on both sides of the users. Annie as Pere's sister and Pere as Annie's brother.

(iv) User Acceptance Test

User Acceptance Test (UAT) was performed by end users in order to test the system before taking into production phase. The UAT is last phase of all the testing. In this study, users were testing MyFam Mobile application to verify if it meets their requirements.

3.8.6 System Validation

Validation of the system was done by deploying the system to few representative and let them interact for a period of five days.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Characteristics of the Respondents

The characteristics of respondents show that 40% were male while 60% were female. The result in Fig. 11 indicates that female participated in our study more than male.

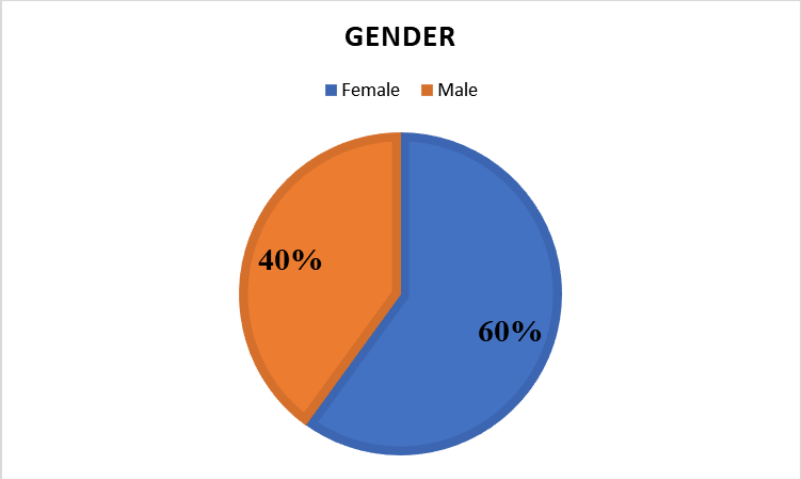

Figure 11: Characteristics of respondents

4.2 Descriptive Analysis Results from the Survey

The structured online questionnaire as shown in Appendix 1, was used to collect quantitative data from families in Tanzania. The questionnaire was developed using both English and Swahili language that aimed at answering questions related to family relationship in Tanzania. A total of 97 responses were received from the participants. The following sections provide the results of findings.

4.2.1 Respondents' on Discovering Family Members

People use several ways to get to know or find further about their distant relatives. According to the findings of the study, 83.5 % are introduced to distant relatives by close family members. A mother, for example, introduces her children to their uncles, aunties, and so on. Also,33 % use family occasions to know their relatives, and 23.7% make an effort also know their distant relatives. This result entails that most of the families use close families and family occasions get to know each other (Fig. 12).

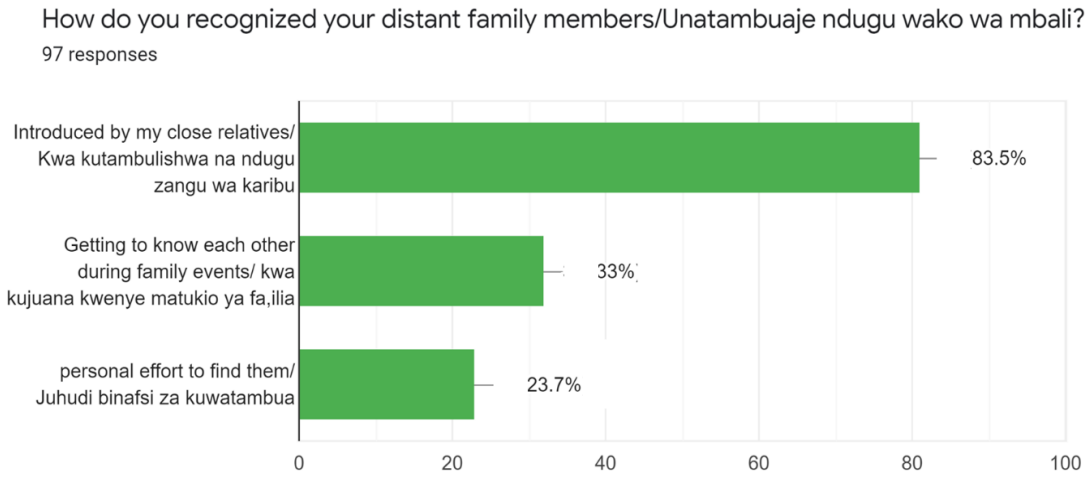

Figure 12: Respondent's on family discovery

4.2.2 What Brings People Closer to their Distant Relatives?

The study aimed to understand different ways used by people who are getting to know their distant relatives.

Results revealed that 68 % of the respondents occasionally meet on family gatherings while, 23.7% they are visiting each other. This result entails that most of the families use family occasions and communication using mobile phones platforms to discover their distant family members (Fig. 13).

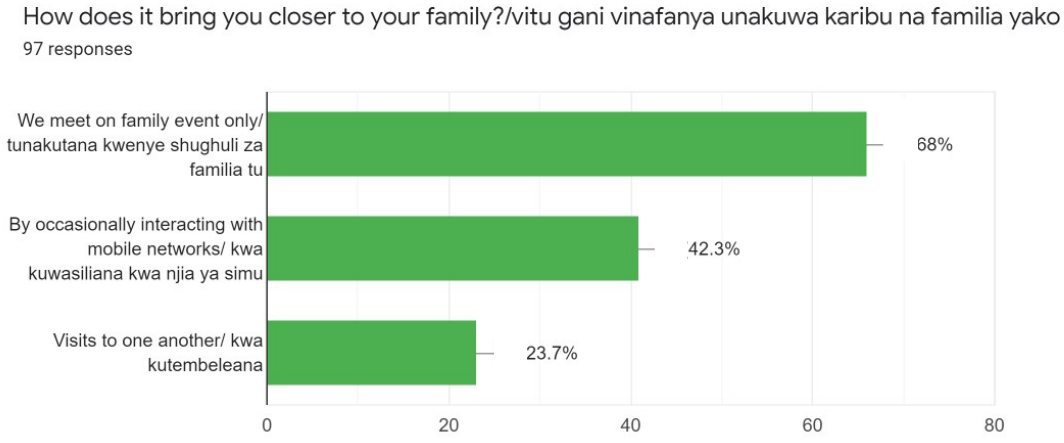

Figure 13: Respondents on what brings people close to their relatives

4.2.3 Respondents on Use of Social media to Discover Family Members

Existing social media platforms are one of the platforms that people use to connect and virtual interact with different people they know. The study observed that 72 % do not normally use social media to discover their family members, while 4% use social media to discover their distant relatives (Fig. 14).

This result indicates that existing social media platforms are not designed specifically for discovering specific ones' relatives; instead, everyone is regarded as a friend, making it even more difficult for people to choose existing social media platforms as a platform for effectively discovering their family members.

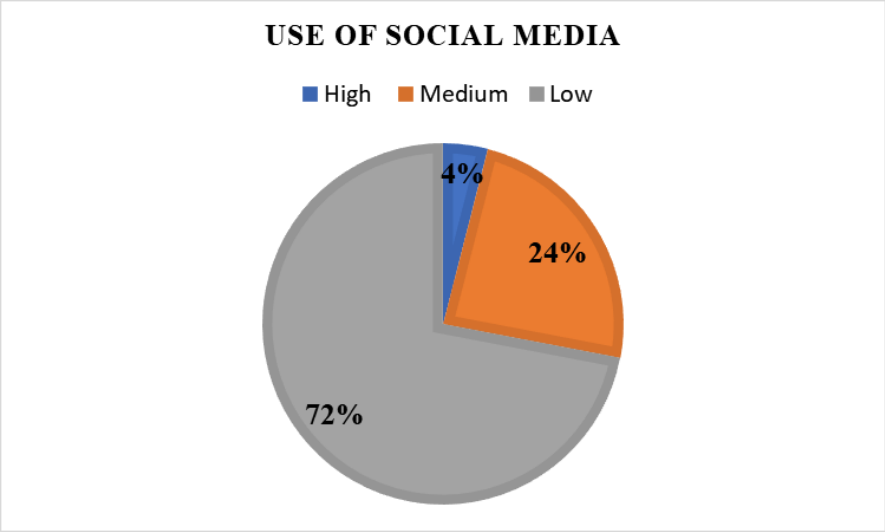

Figure 14: Respondents on use of social media

4.2.4 Respondents on Language Preference

Tanzania has unique names based on a relationship that can be used, as was indicated by Table 1. Based on today's mixed culture (modern and traditional culture), the goal of this survey was to identify which language is preferred by people to be used when calling someone based on their relationship. Results showed that 64% of respondents prefer to use Swahili while, 9% of respondents use exclusively English words (Fig. 15). These findings were incorporated as one of the system requirements, requiring users to select their preferred language when using the mobile application.

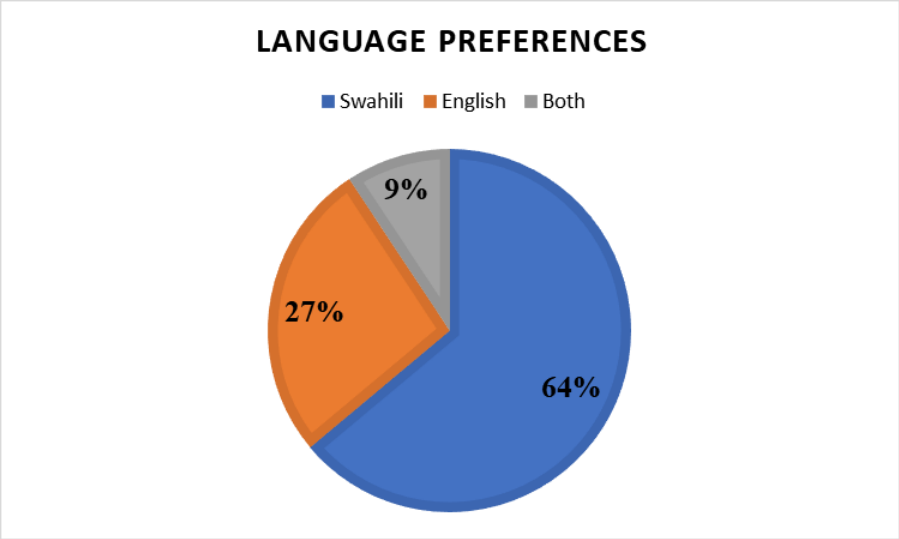

Figure 15: Respondents on language preferences

4.2.5 Respondents on Necessity of Discovery Distant Family Members

The study also observed that 90% of the respondent's people see necessity of discovering their other distant family members, while 10% of the respondents see no necessity (Fig. 16).

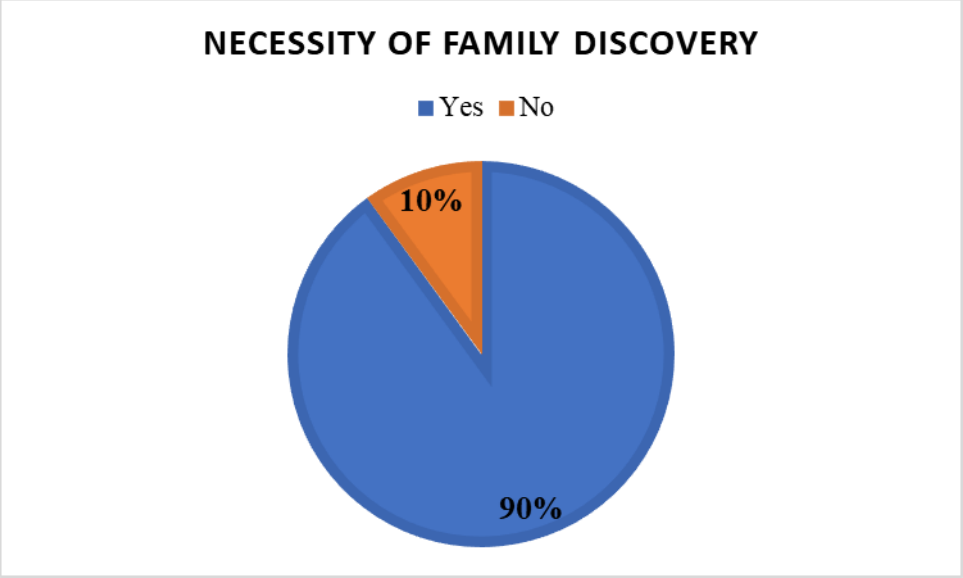

Figure 16: Respondents in necessity of discovery distant relatives

4.3 System Requirements Identification

The identified requirements are categories into function and non-function requirements as shown in Table 2 and Table 3 respectively.

Table 2: Functional requirement of the proposed system.

S/N	Requirement	Description
1	User's authentication	The system will verify user through user phone number using verification codes and the user's phone number will be stored on database whereby user will only register once using the same phone number.
2	New relation submission	User will have to submit to new relationship with their phone number.
3	Relationship discovery	System should allow user to receive notification for a new relationship and whether to ACCEPT or REJECT the request.

Table 3: Non-functional requirement of a proposed system

No.	Requirement	Description
1	Security	System should permit only authenticated users to access the system and on.
2	Performance	The system should support interactions of relationship discovery.
4	Accessibility	The system should be accessible both online and offline mode.
5	Efficiency	The system should perform its tasks fast and effectively.
6	Flexibility	The system should be able to add new features before and after deployment.
7	Interoperability	The system should be able to exchange information and communicate with internal and external applications.

4.3.1 Assumptions and Dependencies

The development of MyFam mobile application was based on the following assumptions for software and hardware features.

(i) The user(s) will be a person with the android smartphone.

(ii) The mobile application will be available online.

(iii) The person with no smartphone can receive normal SMS to confirm the request and be able to reply 'YES' or 'NO'.

(iv) The user(s) have good knowledge of smartphones can well interact with the installed application.

(v) Most of the users are using cheap smartphones installed with Android operating system.

(vi) The project will follow agile methodology throughout execution.

4.3.2 Use Case Diagram

Use case diagram depicts the interaction of users and the system. It shows how users interact with the system, their inputs, expectations and the actions that the system must take to meet the objectives. It depicts the use cases, actors and the relationship between them. The use case of MyFam App is shown in Fig. 17. Each of use case shown is described in Table 4.

Figure 17: Use case diagram

Table 4: Description of the use case

Use case	Description
User registration	User(s) must register once when interact with MyFam app.
Add relationships	User(s) must add at least two known relationships with the phone number to discover more people
Accept or reject relationship	User(s) can accept or reject the relationship requested
View other user profile	User(s) can view other people's profile
Send feedback	User(s) can send feedback
Contact us	User can also contact MyFam developers for more help and support

4.4 Rule Based System Design Results

Use case diagram was used to depicts user's interaction and rule-based system architecture was used to visualize the flow of the system (Fig. 18).

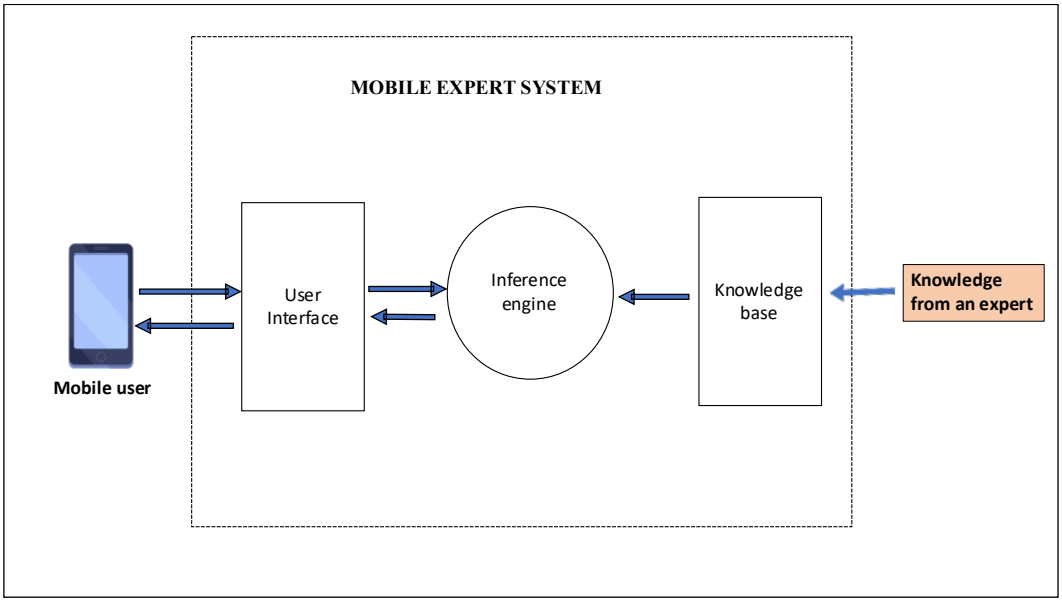

Figure 18: Rule based system architecture

The mobile user interface allows user to interact by providing some basic information such as Full name, gender, phone number and at least two family members that will be used in discovering the relationship. Whenever user sends the relationship through user interface, and the other user confirm the relationship, inference engine performs its function of generating the relationship based on some set of rules.

Inference engine will match the relationship between two people based on the facts in the knowledge base. It then displays the relationship produced by inference engine to user. Inference engine finds information and relationship from the knowledge base and thus provides answers or suggestions in a way similar to human expert.

The knowledge based provides a relational database and it also have a working memory which stores the rules and facts for the system. The rules stored are always in the form of IF-THEN statements as shown in Fig. 19**.**

The rules, facts were generated and queries were deployed in prolog console as show below

```
/*Facts*/
male(jack).
male(oliver).
male(ali).
male(james).
male(simon).
male(harry).
female(helen).
female(sophie).
female(jess).
female(lily).
parent_of(jack,jess).
parent_of(jack,lily).
parent_of(helen, jess).
parent_of(helen, lily).
parent_of(oliver,james).
parent_of(sophie, james).
parent_of(jess, simon).
parent_of(ali, simon).
parent_of(lily, harry).
parent_of(james, harry).
/*Rules */
father_of(X,Y):- male(X),
   parent_of(X,Y).
```

```
mother_of(X,Y):- female(X),
   parent_of(X,Y).
grandfather_of(X,Y):- male(X),
   parent_of(X,Z),
   parent_of(Z,Y).
grandmother_of(X,Y):- female(X),
   parent_of(X,Z),
   parent_of(Z,Y).
sister_of(X,Y):- %(X,Y or Y,X)%
   female(X),
   father_of(F, Y), father_of(F,X),X \= Y.
sister_of(X,Y):- female(X),
   mother_of(M, Y), mother_of(M,X),X \= Y.
aunt_of(X,Y):- female(X),
   parent_of(Z,Y), sister_of(Z,X),!.
brother_of(X,Y):- %(X,Y or Y,X)%
   male(X),
   father_of(F, Y), father_of(F,X),X \= Y.
brother_of(X,Y):- male(X),
   mother_of(M, Y), mother_of(M,X),X \= Y.
uncle_of(X,Y):-
   parent_of(Z,Y), brother_of(Z,X).
ancestor_of(X,Y):- parent_of(X,Y).
ancestor_of(X,Y):- parent_of(X,Z),
   ancestor_of(Z,Y).
```

Queries

```
?-mother_of(jess,helen).
?-brother_of(james,simon).
```

Return: True or False

```
SharedPreferences preferences = context.getSharedPreferences(SUCCESSUSER_PREFERENCES, Context.MODE_PRIVATE);
       verifiedphone = preferences.getString("verifiedphone", null);
       if (productGetters.get(paramInt).getUserphone().equals(verifiedphone)) {
           paramViewHolder.txt_relation.setText("RELATIONSHIP: " + productGetters.get(paramInt).getRelationship());
       } else {
           if (productGetters.get(paramInt).getRelationship().equals("Sister") && productGetters.get(paramInt).getGender().equals("Male")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: BROTHER");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Sister") && productGetters.get(paramInt).getGender().equals("Female")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: SISTER");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Father") && productGetters.get(paramInt).getGender().equals("Male")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: FATHER");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Mother") && productGetters.get(paramInt).getGender().equals("Female")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: MOTHER");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Brother") && productGetters.get(paramInt).getGender().equals("Male")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: BROTHER");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Brother") && productGetters.get(paramInt).getGender().equals("Female")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: SISTER");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Uncle") && productGetters.get(paramInt).getGender().equals("Male")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: Uncle");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Uncle") && productGetters.get(paramInt).getGender().equals("Female")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: Uncle");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Aunt") && productGetters.get(paramInt).getGender().equals("Male")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: Aunt");
           }
           if (productGetters.get(paramInt).getRelationship().equals("Aunt") && productGetters.get(paramInt).getGender().equals("Female")) {
               paramViewHolder.txt_relation.setText("RELATIONSHIP: Aunt");
           }
       }
```

Figure 19: Database of family relationship

4.5 System Development Results

User-friendly mobile application named MyFam was developed to allow family interactions and relationships discovery. The application can be downloaded, free of charge from google play store.

User will first interact with the application by launching the system in a splash screen as seen in Fig. 20, which is a welcome screen that informs users about the essence of the system and lasts for two seconds before landing on the registration page for new users or the home page for registered (existing) users. New user can register personal information including Name, Family name (Preferable), Gender and phone number as shown in Fig. 20. For the authentication process the user should input verification code to be verified successfully.

Figure 20: Splash screen

The system will prompt user to input at least two family members with their relationship and the notification will be sent to the intended person to confirm or reject the request as seen in Fig. 21.

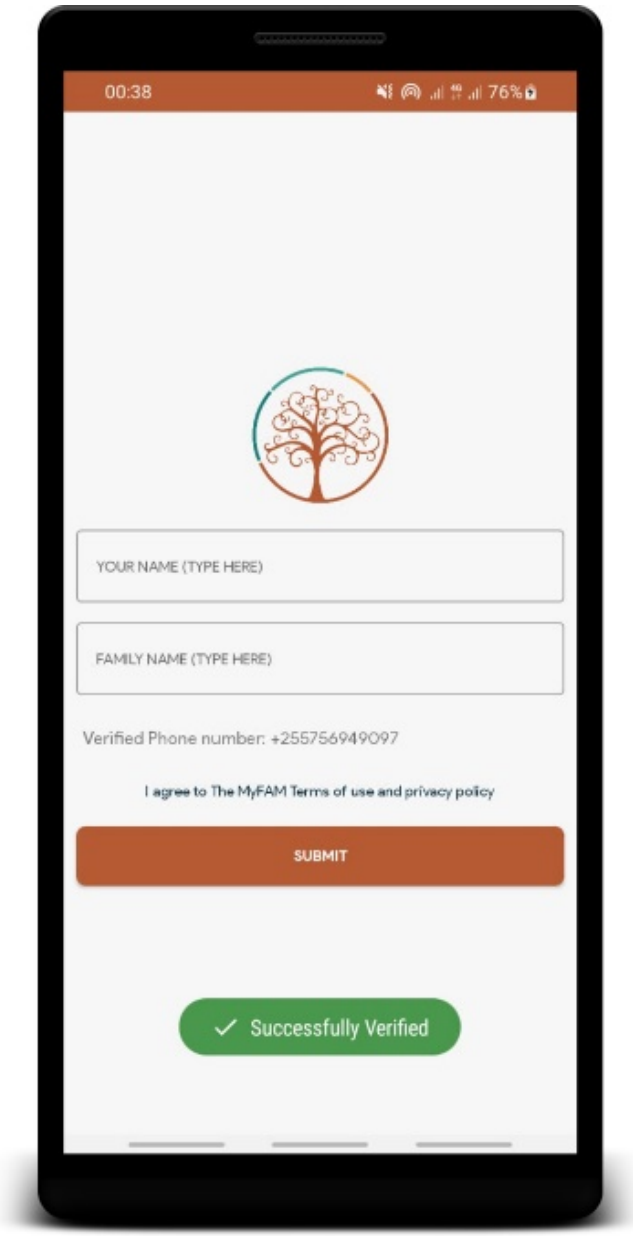

Figure 21: New user registration

When a person is not yet to join in MyFam App, user will be notified before sending the invitation that the selected person has no MyFam account, so person will need to send normal text message to that person to confirm as illustrated in Fig. 22.

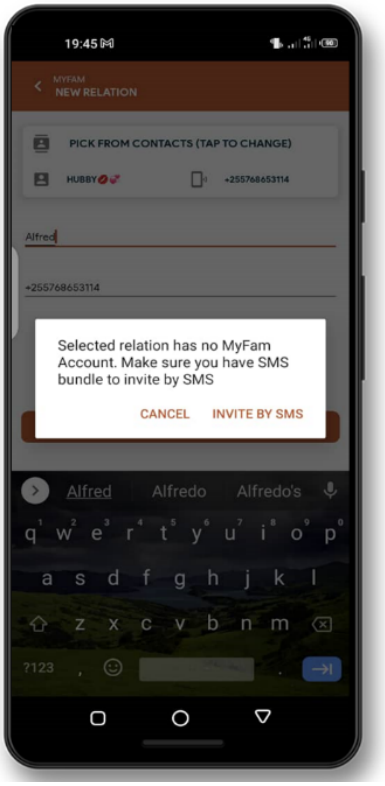

Figure 22: New Relation invitation

For the person who have not yet registered on MyFam App, notification SMS will be sent to confirm the request. Once the request is accepted user can automatically discover new relationship as seen in Fig. 23.

Figure 23: Request SMS for unregistered user

For extending the family tree, the same person will be invited to the platform and add other relationships where all related family members will discover their new family members as seen in Fig. 24.

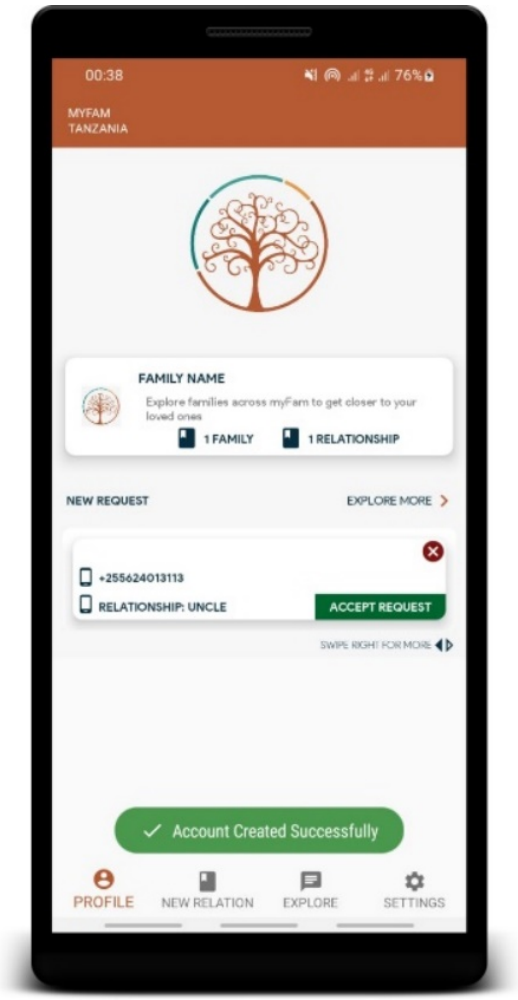

Figure 24: Relation accepted

As the family continue to increase users will have access to start conversations through one another as seen in Fig. 25.

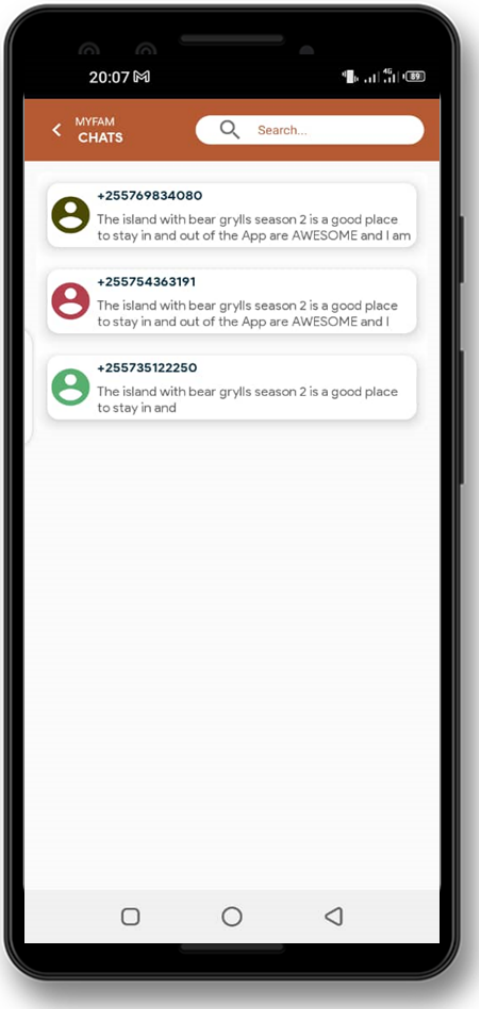

Figure 25: MyFam Chat interface

4.6 System Testing Results

The system was split and tested by each module whether it works effectively and meet user requirements, and all errors were successfully fixed before modules integration. Also, in integration testing bottom-up integration technique was used to check and identify error when two modules are integrated.

4.7 System Validation Results

System validation was conducted to ensure that the developed system meet the requirements through user acceptance testing. The survey was used to validate the developed system where the aim was to assess the system's functionality, interface, and end user experience as shown in Appendix 3. The survey had 20 participants, 55% were female while 45% were male as shown in Fig. 26.

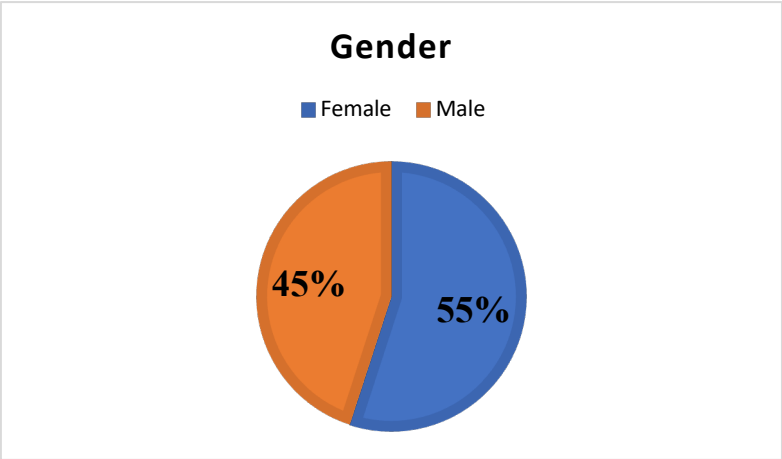

Figure 26: Evaluation respondents according to Gender

(i) User experience

A rating scale of 1-4 were used to evaluate responses in terms of very good, good, fair, and poor. Results showed that 40% of the respondents rated user experience to be very good while, 5% of the respondents rated to be poor as shown in Fig. 27.

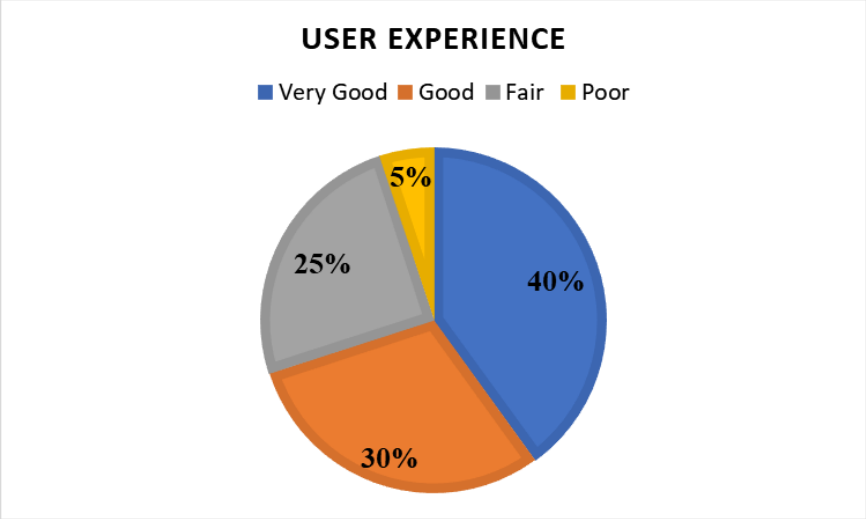

Figure 27: Respondents on user experience

(ii) Evaluation on system functionalities

Functionality of the system was also evaluated so as to identify area to improve throughout the development of application. Also, to ensure the application is working according to the given requirement specifications and there are no functionalities missed in the process of interaction. It was also included to evaluate the app's navigation procedure, search features (sorting option), and app simplicity. Results showed that, in functionality 40% of the respondents rated

functionality of the application to be very good while, 5% of the respondents highlighted the needs for the developed application to incorporate more features as seen in Fig. 28.

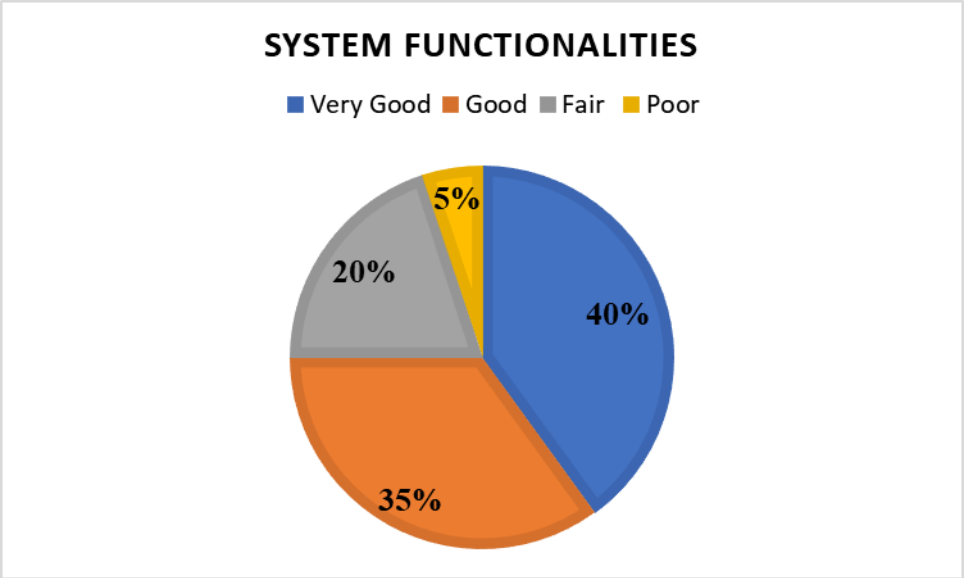

Figure 28: Respondents on functionality of the system

(iii) Evaluation on system interface

The aim was to evaluate how easy and quick an app was to use, how straightforward boarding was, and how satisfied users were with the overall experience. Figure 29 shows that 55 % ranked it as Very Good, 25 % as Good, and 20% as Fair.

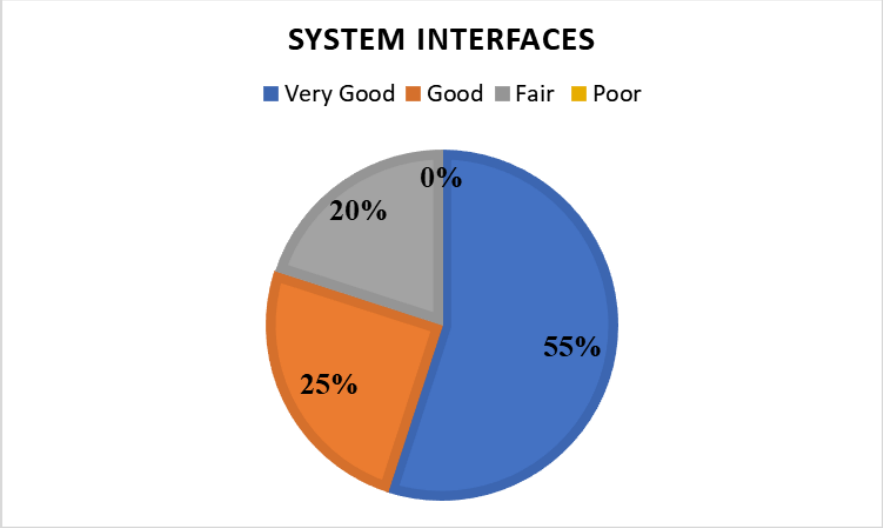

Figure 29: Respondents on system interface

Figure 30 is the summary of the validation of the system basing on user experience, user interface and system functionality.

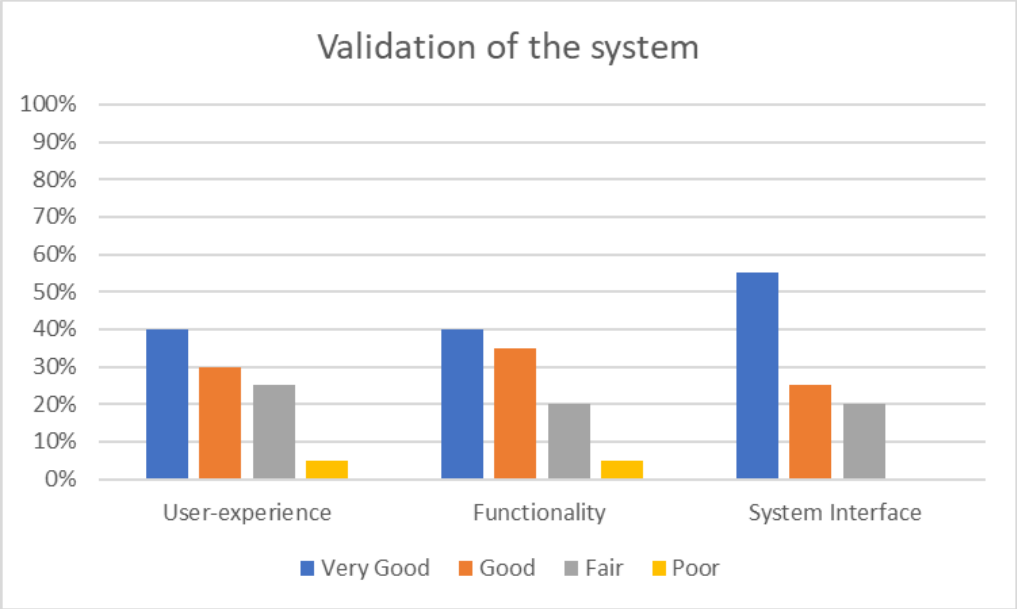

Figure 30: Validation of the system

4.8 Discussion

Most of existing system use genealogical information typically contain large amount of families' information in a database and allow user to enter their individual information and search for people according to name, date or birth. Which might result to false positive information especially when people have same name or even when people have consanguine relationship (women who are married and change their surname). Moreover, in many countries especially in Tanzania there is no enough information in existing genealogical information system which make it difficult or even not applicable when one searching for their relatives. MyFam app ensure the discovery of the family member is does not depends on historical data rather than primarily individual identification of family member whereby the relationship will expand depending on the number of users identify their close relatives and matches with each other.

Furthermore, it has been discovered that the most common route for individuals to contact long-distance people is through communications or social networks, but because the person does not yet know if the person is related, communication might take place within his or her known cycle.

According to the findings, the MyFam App may be used to not only discover people's relationships, but also to explore relationships between long-lost individual people, as well as to relate and exchange information.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the feedback received from respondents, the prototype implementation meets the majority of the users' expectations despite its current limited scope. Additionally, the system accomplished its goals and objectives. The rule-based system was successfully developed using prolog rule which were integrated with MyFam mobile application whereby individual can discover new family members and due to efficacy of the rule-based system, any relationship can be inferred simply and reliably. Moreover, the results were successfully validated to ensure the developed prototype meet the user's requirements.

5.2 Limitations of the Study

Currently the system operates only online for android users so as to receive notifications about the new relationship and intended user can only confirm the request from other people by reply 'YES' as accepting request or 'NO' as reject the request without having more information user can explore before accept or reject.

5.3 Recommendations

5.3.1 To Policy Makers

This platform can be useful to government regulatory such as Registration Insolvency and Trusteeship Agency (RITA) in birth registration records also in National Bureau of Statistics on primary data of household size during census to get the number of family size.

5.3.2 To Governments of Other Countries

Since the main aim of this study was to discover distant family members, the system can also be used in other countries depending on how they name their family relatives based on their relationship so as to reduce false-positive results that are common when using existing genealogical systems to find family relatives. Therefore, this mobile application is recommended to use.

5.3.3 To Practitioners

However, the developed system has only covered the first generation and first cousin horizontally. Furthermore, the system has not yet taken into account other interior cultures such as "kurya" culture, which states that "*if a woman is wealthy, she can marry another woman and be considered as a father, and the children will call her father*."

The system will be more effective when user employ the detail of two people with their relationship information and for user to discover new relationship more people should install MyFam Application.

5.4 Future Work

In the future, there will be improvement of MyFam Application by adding more features to a system so as to be more interactive. Future work will also aim to expand more into visualization of family tree which will best fit the screen space and user can be able to view the hierarchy structure that presents family members.

REFERENCES

Abdallah, M. M., & Al-Rifaee, M. M. (2017). Java Standards: A Comparative Study. *International Journal of Computer Science and Software Engineering*, *6*(6), 146.

Adam, A. M. (2020). Sample size determination in survey research. *Journal of Scientific Research and Reports*, 90-97.

Adewale, A. L., Jumoke, A. F., Adegboye, M., & Ismail, A. (2018). An embedded fuzzy logic based application for density traffic control system. *International Journal of Artificial Intelligence Research*, *2*(1), 7-16.

Affandi, G. R., & Nur Habibah, N. H. (2017). Exploring factors the children's meaning in parents' perspective: Focusing on education, family status, original country, residance and belief system. *Proceedings of the International Consortium of Education and Culture Research Studies, 1*(1), 465-478.

Agwu, O. E., Akpabio, J. U., Alabi, S. B., & Dosunmu, A. (2018). Artificial intelligence techniques and their applications in drilling fluid engineering: A review. *Journal of Petroleum Science and Engineering*, *167*, 300-315.

Al Ahmar, M. A. (2010). Rule based expert system for selecting software development methodology. *Journal of Theoretical and Applied Information Technology*, *19*(2), 143-148.

Alexander, H., Leo, J., & Kaijage, S. (2021). Online and Offline Android Based Mobile Application for Mapping Health Facilities Using Google Map API. Case Study: Tanzania and Kenya Borders.

Alkahlout, M. A., Alsaqqa, A. H., Abu-Jamie, T. N., & Abu-Naser, S. S. (2021). Knowledge Based System for Diagnosing Throat Problem CLIPS and Delphi languages. *International Journal of Academic Engineering Research*, *5*(6), 7-12.

Almadhoun, H. R., & Abu-Naser, S. S. (2020). An Expert System for Diagnosing Coronavirus (COVID-19) Using SL5. *International Journal of Academic Engineering Research*, *4*(4), 1-9.

Armstrong, J. M. (2013). The Family's Role in Society. *Available at SSRN 2291001*. https://dx.doi.org/10.2139/ssrn.2291001

Ball, R. (2017). Visualizing genealogy through a family-centric perspective. *Information Visualization*, *16*(1), 74-89.

Boonnavasin, M., & Rattanatamrong, P. (2016). enGeno: Towards enabling a medical genogram library for supporting home-visit patient diagnosis. *IEEE 5th Global Conference on Consumer Electronics*, 1-4. IEEE.

Borges, J. (2019). A contextual family tree visualization design. *Information Visualization*, *18*(4), 439-454.

Campanelli, A. S., & Parreiras, F. S. (2015). Agile methods tailoring–A systematic literature review. *Journal of Systems and Software*, *110*, 85-100.

Carvalho, J., Francisco, R., & Relvas, A. P. (2015). Family functioning and information and communication technologies: How do they relate? A literature review. *Computers in Human Behavior*, *45*, 99-108.

Cati, A. (2020). From Genealogy to Genetic Memory: Visualising Kinship and Deep Ancestry in Media Imagery. *From Genealogy to Genetic Memory: Visualising Kinship and Deep Ancestry in Media Imagery*, 321-335.

Chari, K., & Agrawal, M. (2018). Impact of incorrect and new requirements on waterfall software project outcomes. *Empirical Software Engineering*, *23*(1), 165-185.

Chen, C., & Rada, R. (2019). Expert System Technology: Expert System Interface. *The Handbook of Applied Expert Systems*, 6-12. CRC Press.

Cho, J. (2015). Roles of smartphone app use in improving social capital and reducing social isolation. *Cyberpsychology, Behavior, and Social Networking*, *18*(6), 350-355.

Chu, T. S. T. (2017). Genealogy Extraction and Tree Generation from Free Form Text. https://doi.org/10.15368/theses.2017.112

Derks, D., Bakker, A. B., Peters, P., & van Wingerden, P. (2016). Work-related smartphone use, work–family conflict and family role performance: The role of segmentation preference. *Human Relations*, *69*(5), 1045-1068.

DeVito, J. A. (2007). *The Interpersonal Communication Book 12th Edition*.

Efremova, J., & Calders, T. (2015). Extraction of family relationships from historical documents. *Dutch-Belgian Database Day 2015, December 16, 2015, Amsterdam, The Netherlands*.

Finch, J. (2007). Displaying families. *Sociology*, *41*(1), 65-81.

Fu, S., Dong, H., Cui, W., Zhao, J., & Qu, H. (2017). How do ancestral traits shape family trees over generations? *IEEE transactions on visualization and computer graphics*, *24*(1), 205-214.

Gafkosoft. (2020). Familiar Names Vocabulary. *Paneli la kiswahili: Swahili Panel.*

Georgas, J. (2003). Family: Variations and changes across cultures. *Online readings in psychology and culture*, *6*(3), 3-16.

Gusarovs, K. (2018). An analysis on Java programming language decompiler capabilities. *Applied Computer Systems*, *23*(2), 109-117.

Haralambos, M., & Heald, R. M. (2009). Sociology, themes and perspectives. *Oxford University Press.*

Haris, M., Jadoon, B., Yousaf, M., & Khan, F. H. (2018). Evolution of android operating system: A review. *Asia Pacific Journal of Contemporary Education and Communication Technology, 4*(1), 178-188.

Hatzilygeroudis, I., & Prentzas, J. (2015). Symbolic-neural rule based reasoning and explanation. *Expert Systems with Applications*, *42*(9), 4595-4609.

Hornstra, M., Kalmijn, M., & Ivanova, K. (2020). Fatherhood in complex families: Ties between adult children, biological fathers, and stepfathers. *Journal of Marriage and Family*, *82*(5), 1637-1654.

Hsu, C. C., & Lin, C. C. (2020). Framework and conceptual design of rule base for building SWI-Prolog-based expert systems to diagnose and treat anxiety. *International Conference on Pervasive Artificial Intelligence,* 54-57.

Hübler, M., & Hartje, R. (2016). Are smartphones smart for economic development? *Economics Letters*, *141*, 130-133.

Isinkaye, F. O., Soyemi, J., & Awosupin, S. (2017). A mobile based expert system for disease diagnosis and medical advice provisioning. *International Journal of Computer Science and Information Security*, *15*(1), 568-572.

Joseph, L., Neven, A., Martens, K., Kweka, O., Wets, G., & Janssens, D. (2020). Measuring individuals' travel behaviour by use of a GPS-based smartphone application in Dar es Salaam, Tanzania. *Journal of Transport Geography*, *88*, 102477.

Kamley, S., Jaloree, S., & Thakur, R. (2016). Performance comparison between forward and backward chaining rule based expert system approaches over global stock exchanges. *International Journal of Computer Science and Information Security*, *14*(3), 74.

Kornaś, D. (2021). Analysis of data storage methods available in the Android SDK. *Journal of Computer Sciences Institute*, *21*, 378-382.

Maríк, R. (2016). On Large Genealogical Graph Layouts. *Information Technologies - Applications and Theory ,* 218-225.

Martín, A., León, C., Luque, J., & Monedero, I. (2012). A framework for development of integrated intelligent knowledge for management of telecommunication networks. *Expert Systems with Applications*, *39*(10), 9264-9274.

Masri, N., Sultan, Y. A., Akkila, A. N., Almasri, A., Ahmed, A., Mahmoud, A. Y., Zaqout, I., & Abu-Naser, S. S. (2019). Survey of Rule-Based Systems. *International Journal of Academic Information Systems Research*, *3*(7).

Mathias, A., & Daniel, M. (2018). Challenges and coping strategies of orphaned children in Tanzania. *Utafiti Journal*, *9*(1&2).

Mohammad, A. H., & Alwada'n, T. (2013). Agile software methodologies: strength and weakness. *International Journal of Engineering Science and Technology*, *5*(3), 455.

Mondal, P. (2014). *Family: Meaning, Characteristics, Function and Types*. Your Article Library Retrieved 20 May from https://www.yourarticlelibrary.com/

Mujawar, S., Gawade, S., Shinde, M., Udage, K., & Bhandari, M. (2020). RFID card and coin operated water ATM. *Open Access International Journal of Science & Engineering, 5*(1), 1-3.

Mukaliyev, D. (2015). *Visualizing large genealogies with timelines* (Master's thesis, Itä-Suomen yliopisto).

Musleh, I., Zain, S., Nawahdah, M., & Salleh, N. (2018). Automatic Generation of Android SQLite Database Components. *SoMeT* , 3-16.

Nakane, C. (2019). CHAP. II. The Relation of Village Community to Kinship Structure. *Garo and Khasi*, 29-78. De Gruyter Mouton.

Ndhlovu, M. (2017). Extended Family in Tanzania. http://2.bp.blogspot.com/-J0gd7t2VdIE/VSbBLq07CZI/AAAAAAAAUKA/MIk18tLFISY/s1600

Nerode, A., & Shore, R. A. (2012). *Logic for applications*. Springer Science & Business Media.

Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management*, *53*, 102104.

Nowak-Brzezińska, A., & Wakulicz-Deja, A. (2019). Exploration of rule-based knowledge bases: a knowledge engineer's support. *Information Sciences*, *485*, 301-318.

Nuanmeesri, S., Baitiang, C., & Meesad, P. (2010). Genealogical information search by using parent bidirectional breadth algorithm and rule based relationship. *International Journal of Computer Science and Information Security, 6*(3), 1-6.

Obradovic, N., Kelec, A., & Dujlovic, I. (2019). Performance analysis on Android SQLite database. *18th International Symposium Infoteh-Jahorina,* 1-4.

Pao, W. K., & Lin, C. (2012). Combining expert formula and geometric feature extraction for die design. *International Conference on Production, Energy and Reliability.*

Pasha, M. F., San Lee, H., Widhiasi, A., Purba, R., Mansour, A., & Budiarto, R. (2020). Neural Nework-based Mobile App Framework to Aid Resource-poor Setting Community Health. *International Conference on Computing and Information Technology,* 1-5.

Peng, Y., Jiang, H., Li, R., & Peng, Z. (2020). PZXG: A genealogy data service platform for kinship management and application. *IEEE International Conference on Knowledge Graph,* 505-512.

Schiefer, D., & VanderNoll, J. (2017). The essentials of social cohesion: A literature review. *Social Indicators Research*, *132*(2), 579-603.

Sharaievska, I., & Stodolska, M. (2017). Family satisfaction and social networking leisure. *Leisure Studies*, *36*(2), 231-243.

Siqueira, E. S., Kabongo, P. C., & Weigang, L. (2016). Comparison study between chinese family tree and occidental family tree. *Distributed Computing and Artificial Intelligence, 13th International Conference*, 61-69. Springer, Cham.

Statistics, C. B. O. (2012). National population and housing census 2011. *National Report*, *1*, 211-225.

Syaifudin, Y. W., Funabiki, N., Kuribayashi, M., Mentari, M., Saputra, P. Y., Yunhasnawa, Y., & Ulfa, F. (2021). Web application implementation of Android programming

learning assistance system and its evaluations. *IOP Conference Series: Materials Science and Engineering*, *1073*(1), 012060.

Taipale, S. (2019). *Intergenerational connections in digital families*. Springer.

Todd, G., Msuya, I., Levira, F., & Moshi, I. (2019). City Profile: Dar es Salaam, Tanzania. *Environment and Urbanization ASIA*, *10*(2), 193-215.

Venkatasubramanian, V., Rengaswamy, R., Kavuri, S. N., & Yin, K. (2003). A review of process fault detection and diagnosis: Part III: Process history based methods. *Computers & Chemical Engineering*, *27*(3), 327-346.

Walek, B., & Spackova, P. (2018). Content-based recommender system for online stores using expert system. *IEEE First International Conference on Artificial Intelligence and Knowledge Engineering,* 164-165.

Walsh, F. (2015). *Strengthening family resilience*. Guilford publications.

Yar, K. T., & Tun, K. M. L. (2016a). Calculating time complexity for searching connections among persons from Myanmar census data using graph database. *Eighth International Conference on Advanced Computational Intelligence,* 200-207.

Yar, K. T., & Tun, K. M. L. (2016b). Searching Personnel Relationship from Myanmar census data using Graph database and Deductive Reasoning prolog rules. *International Conference on Computer Communication and Informatics,* 1-7.

Zahran, S. K. A. E. K. (2011). Type of parental socialization across cultures a psychoanalysis review. *Psychology*, *2*(05), 526.

APPENDICES

Appendix 1: Survey Questionnaire for System Requirements

1. How do you recognized your distant family members/Unatambuaje ndugu wako wa mbali? *

   Check all that apply.

   - [ ] Introduced by my close relatives/ Kwa kutambulishwa na ndugu zangu wa karibu
   - [ ] Getting to know each other during family events/ kwa kujuana kwenye matukio ya fa,ilia
   - [ ] personal effort to find them/Juhudi binafsi za kuwatambua

   Other: [ ] _____

2. What language do you usually use to refer to your siblings by their relationship names with you?/Unatumia lugha gani kuita ndugu zako kwa mahusiano yao na yako? *

   Mark only one oval.

   - ◯ Swahili (mf. Mjomba , Baba Mdogo , Mama Mdogo, Shangazi, Binamu n.k)
   - ◯ English (Uncle,Aunt, Cousin e.t.c)
   - ◯ Both

3. How close are you to your distant relatives?/Ni kwa kiwango gani upo karibu na ndugu zako wa mbali *

   Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

4. How does it bring you closer to your family?/vitu gani vinafanya unakuwa karibu na familia yako *

   Check all that apply.

   - [ ] We meet on family event only/ tunakutana kwenye shughuli za familia tu
   - [ ] By occasionally interacting with mobile networks/ kwa kuwasiliana kwa njia ya simu
   - [ ] Visits to one another/ kwa kutembeleana

   Other: [ ] _____

5. How often do you discover your distant relatives using social media (Facebook, Whatsapp, Instagram)?/ kwa kiwango gani unatumia mitandao ya kijamii kwa ndugu zako *

Mark only one oval.

	1	2	3	4	5	
low/ kidogo	◯	◯	◯	◯	◯	High/ kikubwa

6. Is it necessary to discover even more of your distant relatives?/ kuna umuhimu wa kutambua ndugi zako wa mbali *

Mark only one oval.

- ◯ Yes/ndio
- ◯ No/hapana

Appendix 2 : Android studio sample source codes

```
    BottomNavigationView.OnNavigationItemSelectedListener
mOnNavigationItemSelectedListener
        = new BottomNavigationView.OnNavigationItemSelectedListener() {
    @Override
    public boolean onNavigationItemSelected(@NonNull MenuItem item) {
      switch (item.getItemId()) {
        case R.id.navigation_account:
          startActivity (new Intent (MainActivity.this, AccountActivity.class));
          return true;
        case R.id. navigation_livechat:
          startActivity (new Intent(MainActivity.this, ChatActivity.class));
          return true;
        case R.id.navigation_requests:
          startActivity(new Intent(MainActivity.this, NewRelationActivity.class));
      return true;
```

Appendix 3: Survey Questionnaire for System Validation Test

System Validation Test

* Required

1. Gender *

Mark only one oval.

- ◯ Female
- ◯ Male

2. Are an expert in mobile technology *

Mark only one oval.

- ◯ Yes
- ◯ No

3. How was your experience in using MyFAm App *

Mark only one oval.

- ◯ Very Good
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Other: _____

4. How easy was it for you to manage the application? *

Mark only one oval.

- ◯ Very Good
- ◯ Good
- ◯ Fair
- ◯ Poor

5. How would you rate the design of the app? *

Mark only one oval.

- ◯ Very Good
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Other: _____

6. How would you assess data input options and interactions within the Application *

Mark only one oval.

- ◯ Very good
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Other: _____

Appendix 4: Poster Presentation

Mobile-Based Application for Discovering Family Relationships Using Rule Based System in Tanzania

1.Aina Kipendaroho 2. Dr. Neema Mduma 3. Dr. Elizabeth Mkoba

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Centre of Excellence for ICT in East Africa

Introduction

Family is a social institution which is a basic unit in society. Traditionally, two parents raise their children. Unlike other organizations, family bonds survive longer and provide a primary sense of belonging. In today's world of complex family structures, cultural modernity, and geographic mobility, it is difficult to find distant relatives using traditional approaches.

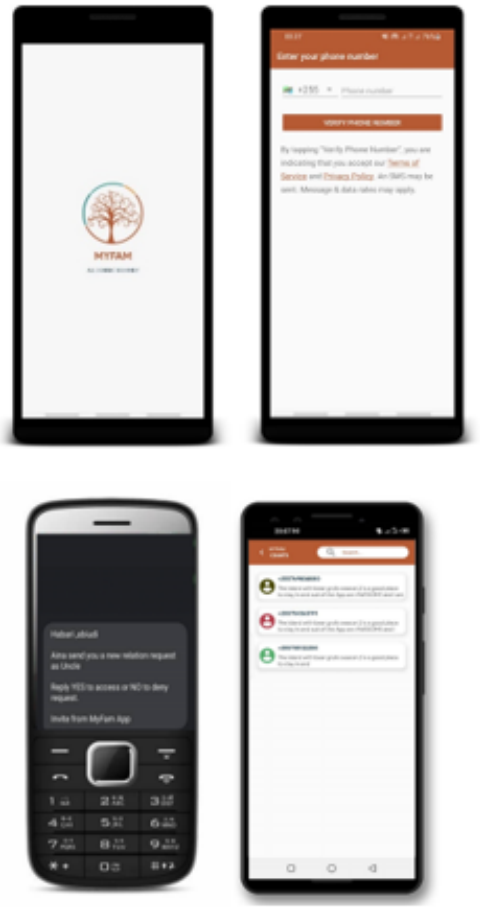
Problem statement

It has been observed that it become difficult when extended family become complex to find distant relatives using traditional approaches this is due to rural-urban migration and residential mobility, which has been weakened family relationship. Several researchers have developed systems to help relatives in discovering their family relationships using genealogical data, nevertheless, these systems may provide false-positive findings when there is lack of information. In Tanzania the genealogical sites have insufficient individual's family information for family discovery.

Solution

To develop an integrated and interactive mobile-based system that will map the family information pattern based on the primary number of people provided by the user, with the family tree expanding as more users identify other people fit the same pattern. The system will utilize rule-based system to identify name or type of relationship. The system interface is user-friendly and effective, and allowing quick user adoption.

Results



Conclusion

The system was validated with users, where results emphasized its efficiency as a discovery tool with performance of 40% in user experience, 40% in system functionalities and 55% in system interface. The contribution of this study is to provide a mobile application that can be used in many countries for discovering family members relationships. In addition, due to efficacy of the rule-based system, any relationship can be inferred simply and reliably based on how family relationships are named.