

Arabic Goal-oriented Conversational Agent Based on Pattern Matching and Knowledge Trees

Zaid Noori, Zuhair Bandar, Keeley Crockett

Abstract- Conversational Agents (CA's) are computer agents used in applications to converse with humans using natural language dialogues. They are widely used in different fields like industry, education, marketing, health, and other services. Goal Oriented Conversational Agents (GO-CAs) are agents having a deep strategic purpose which enables them to direct conversations to achieve a certain goal using a specific domain. Typically (CA's) are programmed to have a set of rules that guide the conversation with the user. One technique used to script CA's is through pattern matching algorithms. Such algorithms are used to match the user's dialogue and instigate the conversation through writing a series of scripts that contains the rules and patterns relevant to the domain. Throughout the conversation, values can be extracted from the user's dialogue which allows the CA to respond with the correct answer. CA's have been mainly developed for the English language and very limited work has been carried out in Arabic. This is mainly due to the complexity of the language and the lack of resources supporting the Arabic language. This paper proposes a new CA architecture based on a pattern matching algorithm for the development of a goal orientated Arabic Conversational Agents (ACA). The ACA incorporates a new scripting language and knowledge engineering is used to construct the domain. A prototype ACA was developed and the Iraqi passport system was used as a domain to evaluate the new ACA. The ACA was tested and evaluated by experts within the Iraq Consulate with encouraging results and received positive feedback.

Index Terms- Conversational Agent, Goal Oriented, Goal Oriented Arabic Conversational Agent, Pattern matching.

I. INTRODUCTION

The idea of engaging machines to communicate with humans was inspired by the Turing Test in 1950 [1]. Since then a lot of researchers have worked to change this idea into reality. A Conversational Agent (CA) is an agent which uses natural language dialogue to communicate with humans [2]. It has also the ability to reason and pursue a course of action based on its interaction with humans and other agents [3]. The first CA's were known as Chatbots and were designed with the sole aim of holding and maintaining a conversation with users which was often aimless [4].

Zaid Noori

PhD student, School of Computing, Mathematics and Digital
Technology, Manchester Metropolitan University
E-mail: zaid.noori@stu.mmu.ac.uk

Zuhair Bandar

Retired Prof, School of Computing, Mathematics and Digital
Technology, Manchester Metropolitan University
E-mail: zbandar@hotmail.co.uk

Keeley Crockett

Senior Lecturer, School of Computing, Mathematics and Digital
Technology, Manchester Metropolitan University
E-mail: K.Crockett@mmu.ac.uk

More recently, Goal Oriented Conversational Agents (GO-CA) were developed to focus the conversation on a particular business [5]. GO-CAs, like other CA's, offer the ability to provide 24/7 consistent support and advice to the user regardless of their computer skills and ability.

They can also provide individual interactions with a different number of users simultaneously. Some good examples of CA's are those used in sales services, education, student debit advisor, and bullying and harassment polices [6, 16].

Traditionally, CA's are scripted using traditional Pattern Matching (PM) algorithms [5]. These algorithms operate on a set of rules organized into contexts that represent the domain; The CA matches each user utterance to patterns within the rules where the highest scoring rule causes a response to the user to fire. Conflict resolution strategies exist within most CA engines to deal with rules that score the same. The main issue with pattern matching is that each domain can take substantial time to script and must be done by domain experts with excellent linguistic skills.

Although the Arabic language is spoken by more than 350 Million all over the world, being the language of the Holy Quran, and also one of the six languages accredited in The United Nations Agencies, it lacks real and active researches in both language resource and CA development. Arabic Conversational Agents (ACA) using Pattern Matching or any other techniques are also rare. little work has been done in developing Arabic CAs [7]. ArabChat [7] was designed at first to act as an Arabic Conversational agent using the same principles as the traditional CA. However, when tested, it was found that it has some weaknesses like irresponsiveness, domain limitation, and inconsistent dialogue flow, in addition to the complexity associated with scripting, maintaining and managing the CA. The new Arabic Goal-orientated Conversational Agent architecture proposed in this paper is designed to overcome these weaknesses. A new CA architecture is introduced to provide a better dialogue flow, usability, adaptability and responsiveness.

In 2003, the Iraq passport system crashed which caused suffering to Iraqi citizens inside and outside Iraq. It was necessary to establish a new system completely. To overcome this problem, temporary solutions were used, by issuing travel documents, and passports with limited validity period until the system is put back into order. This temporary solution caused other problems in itself. The number of valid official travelling documents and passports were confusing for both Iraqis and International Authorities. The burden of these problems was put on Iraqi missions around the globe. Daily phone calls and visits to consular sections by Iraqi immigrants and citizens to inquire about

the passport services (issuing, renewal, replacing, etc.) was necessary. The new passport service was taken as the case study to build an Arabic conversational agent for Iraqi's living abroad and will be taken as the experimental domain in this paper.

This paper is organized as follows: section II provides an overview of related work in CA's. Section III describes the architecture of the proposed ACA. Section IV describes the passport service domain and Section V provides details of the knowledge engineering phase. Section VI describes the evaluation of the agent using a pilot study. Finally, section VII concludes by looking at the future use of the agent in a real live environment.

II. CONVERSATIONAL AGENTS

A. Related works

Conversational Agent can be divided into two main types, Embodied Conversational Agent (ECA), and Linguistic Conversational Agent (LCA). ECA's are usually characterized by a multimedia interface which includes facial display, hand gestures, posture, etc. interaction with a human (or representative of a human in a computer environment). ECAs are generally used in applications where risks and impact are not significant if the CA does operate improperly [8,9]. ECAs are complex with a relatively limited number of dialogue tasks. Linguistic Conversational Agents (LCA) are usually categorized into the following: Spoken Dialogue Systems (SDS): In which a speech conversation with the agent is converted to a text through speech recognition algorithms. This type of CA's is insufficiently developed and not commonly used due to the relatively high error rates when converting audio input to text [10]. Chatterbots: In which pattern matching algorithms are used to script conversations with humans, where the aim of this type of CA's is to pass the Turing test (converse with humans successfully for 5 minutes) [11]. There is limited usage of this type of CA's in practical life as they are usually used only to generate conversation with no specific goal.

Goal-Oriented Conversational Agents (GO-CA's) are a type of CA's that have a deep strategic purpose which enable them to direct the conversation to achieve a goal [12]. In this type of CA's, Pattern Matching (PM) is used to search for a string in a piece of text to find all occurrences of these strings inside that text [7]. It is considered as one of the most successful methods for developing CA's that demonstrates or at least gives the impression of some kind of intelligence. To achieve this, knowledge engineering must take place on the domain. From this process knowledge trees are generated and scripted to form the rules used in the CA (patterns and responses). Rules are usually divided into contexts to simplify the management of the CA. During the conversation, rules are scanned to compare their patterns with the user sentences, matched patterns shall be captured and responses shall be fired as a reply to the user. The usage of this type of agent is expanding, especially in marketing and medicine as it offers good services. Short Text Semantic Similarity algorithms (STSS): are also used to develop (GO-CA's) [20]. Essentially, pattern matching algorithms are replaced with sophisticated algorithms for the

measurement of Short Text Semantic Similarity [13]. A semantic similarity measure would interpret the semantic content of the sentence as opposed to its structural form. This means fewer patterns are needed in each rule. Throughout the applications of semantics the quantity of scripting can be reduced (patterns) and the user inputs are then matched against the natural language sentences of each rule [20]. The use of such measures is in its infancy and only been trialed on English CA's.

B. Arabic Conversational Agents

As mentioned previously, little work has been achieved in the development of Arabic Conversational Agents. Hijjawi et al, [7] developed the first known Arabic agent known as Arabchat. Arabchat used pattern matching algorithms and classified users' utterances as either question or non-question in order to improve matching. The prototype agent was developed for the Applied Science University (ASU) in Jordan to work as an information point advisor for their visitor students who are Arabic native speakers. Some good trials were made to test ArabChat and showed some degrees of success. However, amending the scripts in the domain in any way resulted in complex reformulation of rules within contexts and was very time consuming— similar to English CA's [7]. ArabChat represented the first attempt in ACA development. It was simple in design, with very limited information and knowledge. The contexts were poorly organized which led to slow responsiveness of the agent. However, for a first trial it was successful in terms of robustness and usability [7].

C. EVALUATION OF CONVERSATIONAL AGENTS

Evaluation of CA's takes place before releasing them for commercial usage. Both subjective and objective evaluations are usually conducted; however there is no standard methodology adopted by researchers. Evaluation of CA's is mainly done either by distributing a questionnaire to the users trying to reveal their subjective assessment of using the agent or by studying the resulting dialogue [15]. The PARADISE framework [16] was one of the earliest works in creating an evaluation system; it was used to evaluate the DARPA communicator SDS. Chatbot evaluations [21] have also been conducted using a variety of criteria (usability, user satisfaction, Agent credibility, ease of understanding, efficiency, effectiveness, speed, and error rates etc.) that tries to combine subjective and objective measures. Some evaluations tend not to assess all criteria and as there is no benchmark metrics there is no consistency across evaluations. Instead they conclude that evaluations should be adapted to user needs and the application at hand [16].

In this paper, the proposed CA was tested by experts in consular works for both subjective and objective goals. This included its reliability, consistency, speed and its ability to replace the experts or to work as a training tool. Details of the evaluation can be found in section VI.

III. ARABIC GOAL-ORIENTED CONVERSATIONAL AGENT

The AGO-CA proposed in this paper used the pattern matching approach. Knowledge Engineering (described in

section V) was undertaken to structure knowledge in a goal orientated manner. Each node in the knowledge tree was mapped onto a context that contains a series of rules consisting of patterns. Details of the scripting language can be found in sub-section A. The main focus of AGO-CA was to build a modular architecture to provide a robust Conversational Agent with features such as:

- Conversational flow control to ensure the user stays on target to achieve their goal. This is achieved through the creation of knowledge trees (see section V).
- Domain adaptability for ease of maintenance,
- Usability for all audiences regardless of their expertise.

Figure 1 shows the high level architecture for the new AGO-CA.

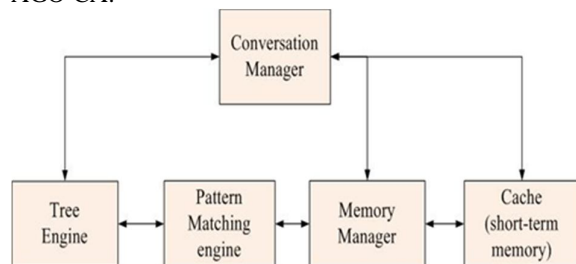


Figure 1 Agent's Architecture

Each component will now be described:

- The Tree Engine is a module responsible for the flow of dialogue towards the goals of the system. This tree engine contains the scripted knowledge tree and also all the required operations and interfaces to search, modify and maintain the tree. The tree engine uses a scripted knowledge tree defined and maintained by the AGO-CA administrator to inspect and interact with users' utterances; all rules of the domain are organized in a hierarchical tree structure. The tree engine also interacts with the Cache; which keeps all the information related to users and fired rules.
- The Pattern Matching Engine is responsible for managing patterns and patterns operations. Pattern matching engine compares the user's utterance against the predefined rules; it's also used to select the best pattern from a group of matched patterns. Higher priority is given to the most appropriate pattern.
- The Conversation manager performs the coordination between other system modules; it also acts as the main interface between the user and other system modules.
- Memory Manager & Cache are modules related to both long-term and short-term memory; The Memory Manager is used to collect user's information and stores them after achieving the user goal for later use.

When a user initiates a conversation, the agent shall act as follows:

1. The User enters natural language text known as an utterance.
2. The conversation manager requests a reply from the tree engine, if no utterance is being processed the tree

engine replies with a query about what the user is requesting help for.

3. When the user answers, his/her utterance is sent to the tree engine for inspection. The tree engine will inspect the utterance by consulting the pattern matching engine to determine which context the user is requesting. Once the tree engine defines the context it inspects the nodes within that context.
4. If there's a direct answer for this query (determined by high scoring patterns) the tree engine fires the associated answer and it will be sent to the conversation manager to be displayed to the user.
5. If that context has more than one option, the tree engine expands the current context and begins a dialogue with a user to gain all required information to be able to provide a appropriate response accordingly.
6. During this dialogue if the user gives an utterance which does not belong to the current context, the tree engine performs a recursive search on all rules defined in the scripted tree to find the appropriate context.
7. If no match is found, the agent shall notify the user and encourage him/her to rephrase the question because the CA did not find the appropriate match.

A. Scripting language

Unlike the mechanism used in Arab Chat which evaluates the user utterance against a set of rules and fires the rule based on a numeric activation level value, the proposed AGO-CA introduces a new technique by organizing the rules in a tree structure where each node represents a context, and each context contains rules related to that context only. This structure provides a consistent method to organize the domain topics. The creation of this tree structure can be found in Section V on Knowledge Engineering. This structure enables the AGO-CA to follow the conversation appropriately and helps the AGO-CA to be fully interactive with the user. For example, when a user has an enquiry and the AGO-CA needs additional information to formulate a response, it fires a query about the possible case (the query usually gives two options, Yes or No). Based on the feedback from the user, the tree can follow the proper tree path and fires the accurate answer.

This new tree structure also reduces complexity associated with assigning a numerical strength and activation level values for each rule, as the AGO-CA automatically controls flow of conversation based on the scripted tree. It also provides optimized usability for the AGO-CA administrator by having a consistent interface and appropriate structure to organize the rules and topics within the domain. This is simply done through enabling the administrator to add, delete, or amend nodes and values on the tree without any effect on the main structure.

Conversational Expert System (CES) have been used in the past [14]. Hence, knowledge trees were adopted for the new AGO-CA. This required development of a knowledge tree tool by which allowed creation of three types of rules, Question Rules, Value Rules, and Report rules.

The question rule is a query question which the agent asks the user for input. The value rule contains a potential answer

along with patterns in which the user might respond; for example consider the following conversation in figure 2.

1. *Agent: welcome to the Consulate Adviser System, how can I help you?*
2. *User: I need a new passport.*
3. *Agent: Do you have valid Iraqi documents?*
4. *User: Yes, I do.*
5. *Agent: Please fill the online form, print it and submit it with four recent photos of you to the passport department at the consulate.*

Figure 2 conversation example

The first and third lines represent Question rules, in which the agent is asking the user. The second line is a value rule, in which the user is giving an answer to the agent.

The fourth line also a value node, but it is context-sensitive it means that the answer “Yes, I do” comes in the current conversation flow. If this reply comes at the beginning of the conversation or in another context, it would be considered invalid.

The fifth line is report node which is the final reply fired by the agent when all the queries are completed.

In addition to the facilities mentioned above, the new architecture provides an almost a real-time responsiveness since the AGO-CA is expecting the potential answers from the user, therefore the AGO-CA does not have to scan and search through all the rules in all the contexts to match an answer. The AGO-CA is also flexible in that, it allows switching from one context to another if the user initiates such a dialogue. Conversation example in figure 3 demonstrates this:

1. *User: I lost my passport, what should I do?*
2. *Agent: When a passport is lost, you must inform the police and make a journal advertisement about losing your passport, then you can visit the consulate to apply for a new passport, Have you done all of these procedures?*
3. *User: I want a transit passport.*
4. *Agent: Transit passports are issued for citizens who have lost their passport and wish to go back to Iraq urgently, they are also issued for Iraqi student's children to travel outside Iraq.*

Figure 3 conversation example

Let’s consider the 3rd line, when the agent is asking the user whether he had completed the legal procedures for losing a passport, the user moves into other context asking about transit passport. As demonstrated the agent is flexible in that it switchers to another context that discusses Transit passports and thus provides the user with the correct response.

IV. IRAQ PASSPORT – DOMAIN DESCRIPTION

A passport is one of the documents that prove the identity of an individual. It becomes the only important document to prove the citizenship when used outside the borders and territory of the native country. Iraqi citizens, especially immigrants, experienced a large number of problems due to frequent changes in Iraqi passports after 2003. The different types of passport forms and the releases of new passports were very confusing. This coincided with the changes in the passport laws. As a result, there were long delays and queues at the Iraqi missions abroad when applying or investigating about passport issues. To make life easier for citizens, and in an attempt to answer their queries and questions in a better and quicker way, an Arabic Goal-Oriented Conversational Agent (AGO-CA) was constructed using the proposed architecture to offer an online service.

The CA can access, interpret and discuss the correct and updated information about the Iraqi Passports, and reply in a natural language on frequently asked questions in natural language and queries of the Iraqis seeking advice about passport services.

V. KNOWLEDGE ENGINEERING PASSPORT SERVICES

Knowledge Engineering is the extraction of information about the domain from different sources like regulations, legislation, experts in the domain and work procedures. In this paper, information about passports was gathered from the Iraqi Passport law [17], Iraqi Citizenship law [18], Consoler Works Reference Guide [19]. In addition to that, information was also collected on work procedures and advice from experts in this field.

The information gathered was engineered to take the form of an organization diagram with six main contexts about the passports (issuing new passports, renewal, extension, correction, sorting lost passports and travel documents). These contexts were sub divided into about 45 sub contexts. The organization diagram was then converted to take the shape of a knowledge tree having Question Nodes, Value Nodes, and Report Nodes. When conversing with the agent, the matched node shall be expanded and considered as a context, and the user is lead through a dialogue flow to the right response by matching the utterance with node patterns saved in the tree. If the user decides to switch from one context to another (ask questions about a different subject), the agent shall search for the nearest context that matches the subject in the user’s utterance. Figures (4, 5) show multi-level knowledge trees in both English and Arabic (for purpose of translation).

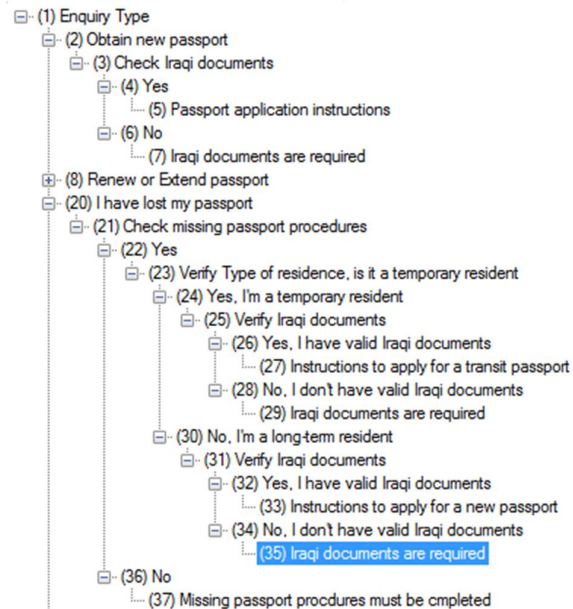


Figure 4. English knowledge tree

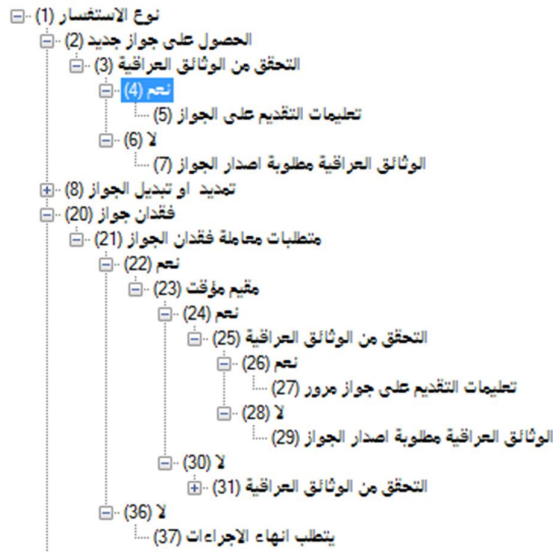


Figure 5. Arabic knowledge tree

A. Conversation Samples

Figures (5 and 6) below show a conversation samples in Arabic and it’s translation in English taken from the agent.

Let’s consider Figure 5. A user is having a problem since he lost his passport, and asking the agent what he should do about that.

The agent then responds asking the user about the completion of legal procedures regarding the loss of his passport.

It’s clear from the conversation sample that the agent is guiding the user through a dialogue to give a correct response and ultimately solving the user’s problem – hence reaching the conversational goal.

<p>User: I lost my passport, what should I do? System: When a passport is lost, you must inform the police and make a journal advertisement about losing your passport, then you can visit the consulate to apply for a new passport, Have you done all of these procedures? You: Yes, I have System: Do you live there for short-term and you want to go back to Iraq? You: Yes, I'm a tourist. System: do you have valid personal ID and Citizenship certificate, or copies of them? You: Yes System: You can send a written request to the consulate to obtain a transit passport, which requires copies of your Iraqi documents and 4 colored personal pictures with white background.</p>	<p>النتج: فقدت جوازى ماذا افعل النظام: عند فقدان الجواز يتخلّب تقديم بلاغ للشرطة عن حالة فقدان ، نشر فقدان في الصحيفة وبعد ذلك يتم مراجعة البعثة لاصدار جواز جديد ، هل قمت بهذه الاجراءات ؟ النتج: نعم قمت بذلك النظام: هل انت مقيم بصورة مؤقتة و تريد العودة الى العراق ؟ النتج: نعم انا سائح النظام: هل تملك هوية الاحوال المدنية وشهادة الجنسية العراقية النافذة او صور ملونه مئمتما ؟ النتج: نعم النظام: يمكنك تقديم طلب خطي الى البعثة بشأن اصدار جواز مرور و يتخلّب وجود نسخ من الوثائق العراقية و صور ملونه بخلفية بضاء عدد 4</p>
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Fig. 5

The conversation sample in figure 6 is another example. When the user responded in a different way to the agents question (negative response), the Agent fires a different response instructing the user on the right procedure before a travel document or a passport can be issued to him.

<p>User: I lost my passport, what should I do? System: When a passport is lost, you must inform the police and make a journal advertisement about losing your passport, then you can visit the consulate to apply for a new passport, Have you done all of these procedures? You: No, I have not System: You must complete these procedures, then you may apply for a new passport or obtain a transit passport to go back to Iraq.</p>	<p>النتج: فقدت جواز سفري ماذا افعل النظام: عند فقدان الجواز يتخلّب تقديم بلاغ للشرطة عن حالة فقدان ، نشر فقدان في الصحيفة وبعد ذلك يتم مراجعة البعثة لاصدار جواز جديد ، هل قمت بهذه الاجراءات ؟ النتج: لا لم افعل بذلك النظام: يجب اكمال اجراءات فقدان الجواز قبل الشروع باصدار جواز بديل، بعد ذلك يمكنك اصدار جواز جديد او اصدار جواز مرور سريع لغرض العودة الى العراق</p>
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Fig. 6

VI. EVALUATION

A. Methodology

The evaluation was conducted through a questionnaire designed especially for this case. It contains some

explanation and instructions on the domain, and how to test and evaluate the agent. It also requests some information about the age, gender, status, and experience of the participants themselves. 13 questions were put in the questionnaire, these questions concentrated on subjective issues (agent speed, conversation flow, time to reach the correct answer etc.), and objective ones (like the domain, possibility of using CA’s to replace humans in consular activities). The questions were rated between (1-5), where (1) shows poor feedback and (5) shows excellent feedback.

It was not easy to find experts in passport issues to evaluate this work. We managed to finally to select only 10 qualified participants. In addition to the instructions mentioned in the questionnaire, participants were given 6 scenarios designed to test the Agent, those scenarios covered the domain contexts. After reading them, they were engaged in a conversation with the AGO-CA. The conversations were captured in a log file for further analysis and computation of the evaluation metrics.

B. Results and Discussion

Table I shows the results of the subjective evaluation. It was clear that the AGO-CA was responding positively with good understanding of the questions with 92.5% accuracy, this mean that misfiring is kept to minimum. The flow of conversation was smooth and the agent managed to reach the goal of the user within a very reasonable time (as indicated the percentage 85%). As for the objective evaluation, it was clear that the possibility of using the agent to replace humans is a little early (only 72.5%); this is mainly due to the culture of people when conversing with passport professionals. The overall evaluation indicated that AGO-CA is impressive. However some further work is needed to make it more acceptable to converse with humans.

Table I: Evaluation Results

Subjective Evaluation	
Item	Rate
Information accessibility	82.5%
Time to reach required information	85%
How well the CA understands user utterance	77.5%
The accuracy of CA answers	92.5%
CA’s ability to correct user utterance	72.5%
The validity of answers given by the CA	87.5%
CA responsiveness	95%
CA ability to control dialogue flow during conversation	85%
Overall rate	84.68%
Objective Evaluation	
Item	Rate
How well the CA covers domain topics and issues	77.5%
The possibility of replacing a real passport expert with the CA	72.5%
The possibility of using the CA to provide services to citizens	82.5%
The possibility to use the CA to train consuls	62.5%
Overall rate	73.75%

VII. CONCLUSIONS AND FURTHER WORK

The overall ratings achieved of the objective and subjective tests showed that AGO-CA can be used successfully as a real time tool offering services to different users. An expanding market can be expected if such CA’s are constructed to serve other fields of life. The knowledge tree architecture proposed simplified and facilitated the work of scripters and enabled them to manage changes and variations in an easier way. In addition to that, these AGO-

CA's can be used in training junior diplomats on consular passports activities and becomes a good tool to capture expert knowledge and updated information on the domain.

Although the pattern matching technique is a good tool to run conversational agents, we believe that further work for the Arabic conversational agents is needed using semantic similarity to compare between the two techniques.

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