MUSE: MUltilinguality and SEmantics for the Citizens of the World

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Abstract. This paper discusses some of the challenges raised by multilinguality in the Public Administration field and shows how the MUSE system addresses them by combining speech to text, text to speech, and machine translation techniques, utilizing domain ontologies throughout a complex system designed as a Multi-Agent System and deployed by exploiting resources in the Cloud. The design of MUSE is finished and its implementation and unit testing are under way. On completion of these two stages, MUSE will be experimented in the Registry Office of Genoa Municipality which is supporting this activity by providing the authors with data, advice on the domain, and the opportunity to test MUSE on the field. The final purpose of this work is to make MUSE's services available to all the foreign citizens interacting with Genoa Municipality's Registry Office. The two languages currently supported are Spanish and Italian. Due to the high modularity of MUSE's architecture, a limited effort will be required to add other languages in the future, if the on site experimentation will be successful.

1 Introduction and Motivation

In a world that is becoming smaller and smaller thanks to increasingly efficient and cheap transportation facilities, many persons move for many reasons - tourism, education, migration - and whatever the reason, they are often faced with difficulties because of the lack of understanding of the hosting country's language.

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The MUSE system, whose name originates from "MUltilinguality and SEmantics for the Citizens of the World", aims at supporting a foreign citizen in her attempt to interact with the Public Administration (PA) of the hosting country in her own language.

The user is driven by the system to go straight to the point and do the right moves to achieve her goals towards a happy end transaction with the PA. The user friendly interface has been designed to let the user elaborate her requests in natural language, utter a question and receive a spoken answer in her native language. The answer describes the necessary steps that have to be taken from a bureaucratic point of view (documentations or other offices where to address) in order to complete the life-cycle of the user's request. The user can be asked to reformulate her request in case her question is not clear or is considered out of context by the system. If the question implies that more paths of interaction are possible, and the system cannot decide autonomously which one is correct, multiple choices are proposed to the user for a further refinement. MUSE is able to improve its knowledge of the common requests that can be formulated by users, as it evolves and learns what are the more frequent queries. It also collects all the interactions in order to extract similar patterns of behavior and enriches it for optimization purposes.

MUSE, whose design is completed and whose implementation is under way, will be experimented in the Registry Office of Genoa Municipality.

The paper is organized in the following way: Section 2 presents the architectural, functional, and implementation details of the system, and Section 3 concludes.

2 The MUSE System

MUSE is based on speech translation technologies [1], machine translation [2], ontologies [3], intelligent agents and multi-agent systems (MASs) [4], and cloud computing [5]. The purpose of our work is to make MUSE's services available to all the foreign citizens interacting with Genoa Municipality's Registry Office first, and to other PAs in the future. Spanish and Italian are the languages currently supported inside the system.

As far as the architectural and technological choices behind MUSE are concerned, we decided to integrate some modules as "components out of the shelf" and to treat them as black box items. For example, the Spanish-Italian and Italian-Spanish translations result from the exploitation of the Google Translate service API[1]. This is also done for modularization purposes. Once a change in MUSE is decided, i.e. it has to manage more than one language, it should be sufficient to change the language pair translation in the API, while the formalized part of the system, namely the ontology and the procedural rules, either remains unchanged or just needs to undergo a conservative extension.

Once the user query is uttered in Spanish, transformed into a Spanish text, and translated into the corresponding text in Italian, a query expansion procedure is run to help disambiguate the request and find a match with one of the "well known

[1] `http://research.google.com/university/translate/index.html`

problems" encoded in the MUSE ontology. The query expansion is carried out by means of a translation table, that contains keywords and phrases patterns, each associated with one of their interpretations in terms of ontology concepts.

The sub-domain of practices related with documents proving the identity of a citizen is used in the sequel for better explaining our approach. The ontology which codifies the different "well known problems" that correspond to user requests has been created in Italian which we adopted as "lingua franca" inside the system. Figure 1 depicts a portion of the OWL ontology created with Protégé[2], that results from such codification. The meaning of concepts from the topmost one, and following a left-to-right BFS visit, are: "Identity Card"; "Identity Card of an Adult"; "Identity Card of a Minor"; "Identity Card First Issue"; "Identity Card Renewal"; "Renewal for Personal Data Change"; "Renewal for Address Change"; "Renewal for Expiry"; "Renewal for Loss or Theft"; "Renewal for Deterioration". This is a portion of the actual ontology used in MUSE, and the choice of Italian for representing its concept was due to the need of easing our interaction with the staff from Genoa Municipality, and of providing them with a formalization of their domain that they could feel comfortable with and that could even manage by themselves in the future (providing a suitable user interface). Similar considerations hold for the procedural rules discusses later on in this section, and encoded using strings in Italian.

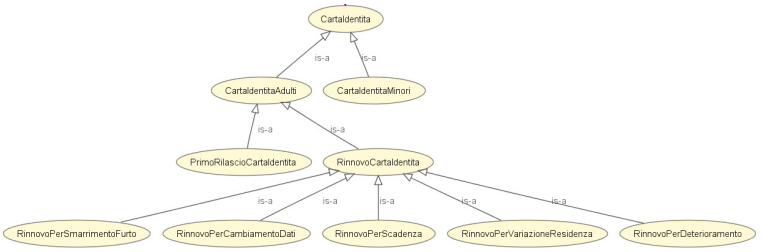

Fig. 1 MUSE ontology for "identity well known problems"

The aim of the ontology is to drive the system to retrieve the correct procedural rule against the user query, once the query has been properly expanded and interpreted. To this aim, the ontology contains all the different paths elicited by the domain experts for the identity card sub-domain. The intermediate concepts are the names of the problems, which have been refined at different levels of depth. The leaves of the ontology represent the head of the procedural rule that codifies the procedure to be activated, once assessed that it corresponds to the procedure associated with the user's request. Such procedural rules are represented as plans in the Jason declarative agent-oriented programming language [6] which is seamlessly

[2] `http://protege.stanford.edu/`

integrated into JADE[3]. Jason turned out to be a very convenient choice both for *representing procedural rules in a declarative, compact, and not ambiguous way*, and for *executing them*. Jason plans corresponding to procedural rules consist of:

- the "triggering event" that must match a leaf concept in the ontology;
- an optional "context" stating under which conditions the plan can be applied;
- the "body" consisting of a sequence of steps necessary to complete the procedure.

Strings starting with "//" are comments.

For example, in case the user formulates a query for a change of address in her identity card, the triggering event of the rule, according to the ontology, will be *"rinnovoPerVariazioneResidenza"* - renewal for address change. The Jason plan that represents the correct procedural rule for dealing with this problem (topmost one in Figure 2) has no context, meaning that is can be always applied, and the steps codified into the rule are *"portareTreFotoFormatoPassaporto"* - provide three passport-sized photos - and *"portareDocumentoIdentitaValidoRecente"* - provide your more recent valid identity card.

Each step is further extended into a set of Jason rules whose triggering event is the step itself, and the context (the atom between the semicolon and the arrow) states which language should be used as the output of the text to speech process. The information of the current language is set at the beginning of the conversation.

Actions in the body of the last four rules shown in Figure 2 are of type ".say": the system that executes the rule must provide a text to speech service and call it when the ".say" action is executed within a body's rule. Actions might be of any kind, including access to information systems and other applications.

Rules in MUSE are codified by hand based on documents produced by Genoa Municipality's Registry Office and on interviews to the office staff.

One of the most challenging activities in the design of multilingual systems is how and where to collect native language utterances and queries that users do while interacting with the tool. For this reason a questionnaire has been prompted and submitted to users in form of short interviews that were conducted at the end of a typical interaction with a human operator, and interactions were recorded (asking the users to sign a module to state that they agree with the recording, and respecting all the norms regulating privacy issues). Both the recorded interactions and the questionnaire are exploited to identify some useful dimensions of the dialog between humans that can drive the system design towards an improvements of such aspects. The questions posed to the user at the end of a session are the following (expressed in the user's native language):

- Which question did you make to the operator?
- Did you obtain the answer you were looking for?

[3] JADE (Java Agent DEvelopment Framework, [7]) is a software framework implemented in Java which provides a middleware and a set of graphical tools that support communication, debugging and deployment of MASs. The agent platform can be transparently distributed across machines. Jason is a platform for the development of MASs developed in Java and supporting different infrastructures for the deployment of MAS including JADE.

```
+!rinnovoPerVariazioneResidenza <- // triggering event
   !portareTreFotoFormatoPassaporto; // step 1 of the rule's body
   !portareDocumentoIdentitaValidoRecente. // step 2

+!portareTreFotoFormatoPassaporto : spagnolo // context ES
   <- .say(es, "Debe proporcionar tres fotos tamano pasaporte").

+!portareTreFotoFormatoPassaporto : italiano // context IT
   <- .say(it, "Portare tre foto formato passaporto").

+!portareDocumentoIdentitaValidoRecente : spagnolo
   <- .say(es, "Debe proporcionar el ultimo documento de identidad").

+!portareDocumentoIdentitaValidoRecente : italiano
   <- .say(it, "Portare un documento d'identita valido recente").
```

Fig. 2 Jason plans for identity card renewal

- How difficult was understanding what you have to do?
- How difficult are the steps that you are now expected to face in order to complete the procedure?
- Was the time you were engaged into the conversation too short, too long or just fitting your expectations?

Some users may do mistakes when formulating their queries. MUSE records such mistakes and the relative correction, and ranks the pairs obtained as they are repeated during real time interactions. In this way the system increases the strength of its hypothesis on the occurrence of such patterns more often than chance, and may provide an automatic correction when the same situation happens again. The users themselves offer feedback when they select their intended request against a set of equally possible requests that the system may show them, hence modifying the ranking of translations based on such feedback for similar queries. In this way the system is able to show as top ranks the most likely translations associated with the most likely requests.

The system, developed in JADE, will be distributed across the cloud thanks to APIs that "Engineering Ingegneria Informatica" has developed for the Java language in collaboration with the DIBRIS Department of Genoa University [8].

3 Conclusions

In this paper we described the MUSE system whose implementation is almost completed, and that will be experimented in the Registry Office of Genoa Municipality.

The foreseen advantages in using MUSE for the Registry Office are that misunderstandings and bad translations troubles should be minimized, as well as the user sense of uneasiness; the difficulties in understanding the answers should disappear, as they will be provided in native language; the queues at the registry office should

be shortened, as the system might contribute to address the users to the right place; as a consequence, latency time might be reduced for Italian citizens as well.

Even if MUSE will be first experimented on the specific Registry Office domain and using Spanish and Italian only, its modular and distributed architecture makes it suitable to provide intelligent speech to speech services, guided by a deep knowledge of the domain, in any scenario and involving any language. Besides adapting MUSE to other PAs, we plan to tackle the "Indiana MAS and the Digital Preservation of Rock Carvings" scenario, in order to allow archaeologists from different countries to interact and share opinions in their own language about interpretation and dating of rock art artifacts. We have already defined some ontologies describing Mount Bego's rock engravings and we have access to a large amount of data and documents [9]. Supporting multilinguality is one of the most challenging objectives of Indiana MAS, and we are confident that MUSE will be the right application for coping with it.

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