A human-computer dialogue system for Māori language learning

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1 Introduction

In this paper we describe Te Kaitito, a bilingual human-machine dialogue system which supports conversational interactions in English and in Māori, the indigenous language of New Zealand. In particular we consider how Te Kaitito can best be incorporated into Mori second language learning experiences.

We begin in Section 2 with a overview of the motivation behind the Te Kaitito system, and its intended role in the continued development of te reo Māori as a working language in New Zealand. In Section 3, we briefly survey the existing applications of natural language processing (NLP) in computer-aided language learning (CALL). In Section 4, we outline the architecture of Te Kaitito, and give some examples of interactions with the system. In Section 5, we describe some proposed extensions of the system to deal with language-learning dialogues, and some initial implementations of these ideas.

2 Developing language technology for indigenous languages

By the 1970s, te reo Māori was on the brink of extinction as a result of societal practices such as school education which emphasised the importance of English (Shuker, [17]: 199). Although by 1996, 22% of the population with Māori ancestry claimed to be able to conduct a conversation about everyday topics in te reo Māori (Benton & Benton, [2]: 423), there are still large numbers of Māori people who want to learn this language but who have restricted opportunities to do so. Also as Aotearoa (New Zealand) is a bi-cultural country under the Treaty of Waitangi, there is a need for other New Zealanders to have an understanding of the culture and language of the Māori people. This is especially true for people employed in government institutions such as schools and health authorities.

To assist with the learning of Māori by Māori and non-Māori alike, we are developing a bilingual English/Māori natural language processing system which is accessible over the web. The system, called Te Kaitito[1], can function either as a sentence translator, in which the user enters a sentence in English and receives a set of translations in Māori (or vice versa), or as a bilingual human-machine dialogue system, in which the user enters and queries facts from a database in either English or Māori. While it is certainly true that the Māori population of New Zealand has less access to the internet than

[1] *Te Kaitito* means 'the improviser', or 'the extempore speaker'.

the population in general, we hope that a web-based system of this kind will be a useful tool in raising awareness of, and improving access to, the Māori language. What is more, the development of a wide-coverage computational grammar for Māori, in addition to the creation of a large online lexicon for the language (see Laws and Kilgour, [13]), are useful in their own right as initiatives to maintain the role of Māori as a working language in New Zealand. In summary, we concur with Villa's suggestion that 'computer technology has the possibility of filling an important niche in minority language maintenance and teaching' ([19]: 8), and we believe that natural language processing technology has a particularly important role to play in this regard.

Although there has been some use of CALL in the teaching of indigenous languages, most of it has been in using other aspects of the computer system such as its ability to facilitate on-line conferencing (Haag & Coston, [7]) and touch screen for the development of L1 literacy programmes (Auld, [1]). By providing Te Kaitito as a web-based resource which anyone can access, it is anticipated that learners will be able to practise dialogues with the system, which can provide expert advice within its own limitations of lexical and syntactic knowledge.

3 Natural Language Processing and L2 Acquisition

The goal of NLP is to develop computer systems which can process natural language in the same way humans do. In many ways this goal can be seen as an end in itself, providing researchers with endless questions which need to be considered and resolved in a satisfactory way (Holland [9]:viii). However, if NLP is considered as a tool which can be used for another purpose, such as second language learning, then other issues also need to be considered and resolved. Second language acquisition (SLA) itself has a research literature which is diverse with no single model seen as the most appropriate (Mitchell & Myles, [15]:ix). However, there does appear to be consensus about the value of **conversational interactions** for language learners in order to improve the comprehensibility of input and the usefulness of output (see Gass, [6]). It is suggested that not just oral interaction but written interaction 'can also develop language, thought and reading and writing abilities' (Peyton, [16]: 17). However in considering how computers can facilitate interaction for language learners, most work has been done on facilitating electronic discussions *between students* (see for example Warschauer, [20]; Peyton, [16]). An exception is Holland, Kaplan and Sams's ([10]) book *Intelligent Language Tutors*, which provides descriptions of a number of systems in which the computer assumes the role of language tutor, and engages in a dialogue with the student, providing feedback about the student's use of language along the way. Although most of these systems were developed without concern for how second languages are acquired, Chapelle ([3]: 25) suggested that programs of this kind have the potential to facilitate language learning through an interactive dialogue. Naturally, the success of such systems depends to a large extent on the development of a flexible human-machine dialogue system. We will consider this issue in Section 4, but first we will consider some of the desirable features of language-learning dialogues.

Mixed-initiative dialogue as a medium for L2 learning

Dialogue is a common medium for ordinary language teaching and learning. A classroom teacher responding to questions, or asking questions, is engaging in dialogue; so is a student attempting a conversation with a native speaker and 'learning by doing' in the process. There are several reasons why dialogue is a useful environment for language learning. Firstly, dialogue happens *in a language*: in the case of an L2 dialogue, the medium of the interaction is itself the topic being learned. Secondly,

dialogue is a means by which both the teacher and the student can shape the learning experience: for instance, the teacher can initiate various kinds of exercise, or the student can ask questions to clarify or extend what they currently know. Finally, the teacher can analyse the student's dialogue contributions to diagnose how well the student has assimilated the material to be learned.

The kind of interaction in which all of these language-learning operations happen is called a **mixed-initiative** dialogue. In this kind of dialogue, both teacher and student have their own (possibly different) educational agendas, and they manage any discrepancies between these agendas by adhering to a common set of conventions specifying how dialogues can be structured. For instance, if one interlocutor takes an initiative by asking a question, the other interlocutor is obliged by these dialogue conventions to respond to this in certain prescribed ways before pursuing any unrelated initiatives of their own.

4 An overview of Te Kaitito

Te Kaitito is a collection of general-purpose NLP modules, which can be combined together in different ways. The modules include:

- A **grammar** and a **lexicon** and a set of **morphological rules** for English, and one for Māori.
- A **sentence parser**, which takes a sentence in either language, and using the above resources, builds a parse tree for the sentence from which a representation of its logical form can be derived.
- A **presupposition resolution module**, which takes the semantic representation of the user's utterance, and determines how to integrate this into its model of the current dialogue context. The semantic representation of a sentence comprises two components. The sentence's **presuppositions** are a set of assumptions the speaker is making about the context in which the sentence is uttered. If all of these presuppositions are satisfied, the sentence's **assertions** can be used to update the dialogue context. A simple kind of presupposition is a pronoun or a definite noun phrase. If a speaker utters the sentence *She chased the dog*, the hearer first has to find a unique salient object in the current discourse context which has feminine gender, and a unique salient object which is a dog. If this is possible, the hearer can then update the discourse context with the information that the former object chased the latter one.
- A **dialogue manager**, which takes the semantic representation of the utterance after it has been integrated and computes a response to deliver. In some cases this response is simply a piece of 'canned text' in the appropriate language—for instance, an acknowledgement like *Okay* or *Ka pai*—in other cases, it is a semantic representation, which in turn has to be passed to the sentence generator.
- The **sentence generator** takes a semantic representation and produces a set of sentences which realise this interpretation in a specified language, using the same grammatical, lexical and morphological resources used by the parser. The system's sentence-processing mechanisms are therefore **bidirectional**; in principle, any sentence it can interpret it can also generate, and vice versa.

Figure 1 gives an outline of how these modules are connected together in the dialogue application. Rounded boxes denote processing modules; square boxes denote data consulted by processing modules. Note that the 'discourse context' is a data resource which is consulted by the presupposition

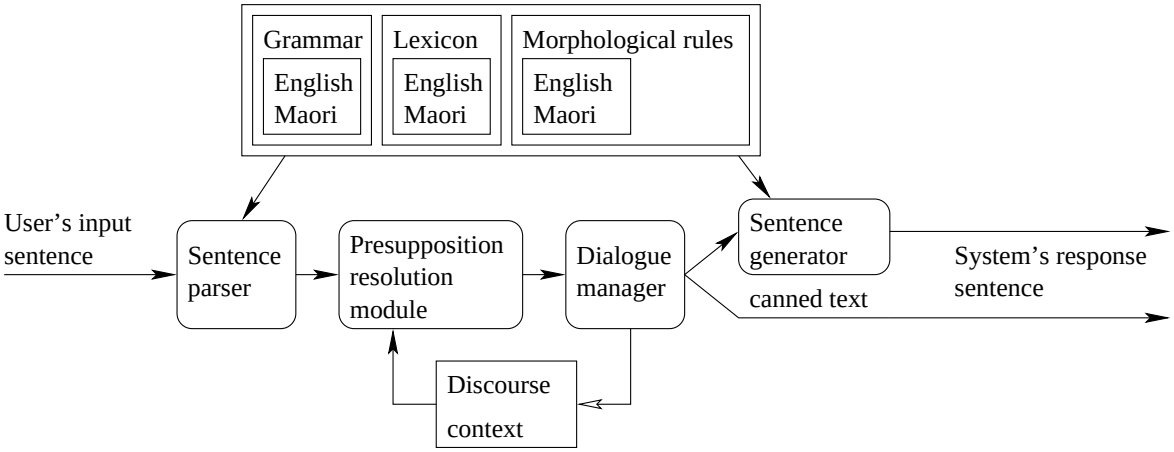

Figure 1: Architecture of Te Kaitito

module and updated by the dialogue manager. For details of Te Kaitito's dialogue management architecture, see de Jager *et al.* ([4]); Knott *et al.* ([11]).

An example of the kind of dialogue Te Kaitito can currently generate is given in Figure 2. In utterances (a) and (b), the user tells the system two new facts, each of which receives a canned text acknowledgement from the system. In utterance (c), the user asks a question, and in (d) the system generates a response sentence. (We have shown all the possible responses it can currently generate; in practice, it normally just produces one of these, in the language which the user has selected.) The user then tells the system several other facts. In utterance (e), the user uses a referring expression whose presuppositions cannot be unambiguously resolved: the system knows about several dogs, and can't decide which is the one intended. So it asks a clarification question in (f), which the user answers in (g). In (h) the system then acknowledges in (h) that it has understood this answer, and in (i) it acknowledges that it has now understood the user's original assertion (e). Utterances (f)–(h) are an instance of a **clarification subdialogue**. The remainder of the dialogue illustrates that the system is able to answer some more complex questions based on the assertions the user has made.

5 Using Te Kaitito to support second language learners of Māori

We have already argued in Section 3 that NLP systems are of potential benefit in CALL applications, and that human-machine dialogue systems are a particularly promising way of making use of NLP technology. Thinking more concretely, how should Te Kaitito be extended to function as a dialogue-based Māori language tutor? We believe three extensions are required, which will be discussed below in turn.

Scenario-based tutorial dialogues

The dialogue in Figure 2 is unnatural, in that Te Kaitito starts off knowing nothing, and can only answer questions based on the facts which the user has told it—which presumably the user knows already! It is more natural to give the system knowledge in some particular domain, some of which can then be presented to the user at the start of a tutorial interaction, so as to introduce a 'scenario' in which the dialogue will occur. Scenario-based dialogues are commonly used in L2 teaching, for

Speaker	Utterance	
User	a blue dog barked	(a)
System	Ok	
User	a red dog walked	(b)
System	Ok	
User	which dog walked	(c)
System	the red dog it was the red dog nä te kurï whero	(d)
User	Ok	
User	the blue dog chased a green cat	
System	Ok	
User	a weasel barked	
System	Ok	
User	a big cat chased the weasel	
System	Ok	
User	the cat barked	
System	Ok	
User	the red dog chased the weasel	
System	Ok	

User	the blue dog walked	
System	Ok	
User	the dog ate the weasel	(e)
System	which dog ate the weasel	(f)
User	the red dog	(g)
System	Ok	(h)
System	Ok	(i)
User	the blue dog chased a slow monkey	
System	Ok	
User	a loud monkey ate the blue dog	
System	Ok	
User	which monkey did the blue dog chase	
System	the slow monkey it was the slow monkey nā te makimaki pōturi	
User	Ok	
User	what chased the monkey	
System	the blue dog it was the blue dog nā te kurī kikorangi	

Figure 2: A dialogue with Te Kaitito

instance in the context of 'information-gap activities' (c.f. Hedge, [8]:58). We have a prototype system for generating initial scenarios from knowledge bases built by human authors, which is described in Knott and Wright ([12]). Our aim is to allow L2 teachers to create their own knowledge bases, tailored to particular skills they want their students to practice.

Error grammars for error diagnosis

It is important that a language tutor be able to identify grammatical errors in the sentences entered by the student during the course of a dialogue, and take action to remedy these (see e.g. Ellis, [5] for some recent evidence).[2] As is well known, if the student is a beginner, it is not helpful to point out every error he makes (c.f. ???). It is preferable if the tutor targets a particular construction, and provides feedback about errors related specifically to this construction (see e.g. ???). Nonetheless, there is still a question about how grammatical errors are *identified* in the student's sentences. Te Kaitito uses a formal grammar to interpret sentences; any sentences outside this grammar are simply uninterpretable, and the system cannot distinguish between them.

An attractive solution to this problem is to develop **error grammars** of Māori which Te Kaitito can learn. An error grammar for a language contains rules which actually allow ill-formed sentences to be parsed. Error grammars have been used quite extensively in NLP approaches to CALL; see e.g. Michaud *et al.* ([14]). The design of our grammar formalism allows error grammars to be specified

[2] We are aware of the current debate surrounding Truscott's ([18]) claim that grammar-correcting feedback is unhelpful, and consequently should not be given. We think that at very least, the gammar-correcting feedback strategies which we implement in Te Kaitito can serve as a method for testing Truscott's claim. Much of his argument is based on an analysis of methodological problems with studies that investigate grammar-correcting feedback, in particular the lack of consistency with which feedback strategies are applied in different experimental conditions. Given that the feedback strategies which we can implement in Te Kaitito are eminently consistent, we think that experiments with our system could have a useful bearing on this discussion.

quite simply, as will be described below.

In Te Kaitito, the grammar and lexicon for English and Māori are currently specified as a single grammar, in which English and Māori words and rules are distinguished by means of a grammatical feature called LANGUAGE. This feature behaves much like a feature like NUMBER or PERSON: agreement is enforced between the different parts of the sentence to ensure that no sentence will be accepted unless the LANGUAGE features for all of its words and rules are the same. A 'bilingual' grammar of this kind is useful, because a sentence can be typed into the parser in either language, and whether it is an English or Māori sentence will determined as a side-effect or parsing: the system just needs to look at the LANGUAGE feature of the top-level constituent in the sentence (the 'S' node) to determine the language of the whole sentence. Another useful feature is that some words can be left undefined for the LANGUAGE feature, and can therefore appear in sentences in both languages. (Proper names are a good example of words which are undefined for LANGUAGE in Te Kaitito. When a proper name appears in a Māori sentence, for instance, feature agreement will force its LANGUAGE feature to the value MAORI.

From the point of view of CALL, the important thing is that error grammars for a language can be identified by a value of the LANGUAGE feature in exactly the same way. To take a concrete example, consider a simple error in Māori. Direct objects in Māori must be preceded by the case-marking particle *i*, as shown in the following example.

Kei te	whai	te	kurī	i	te	ngeru.
Tense/aspect	chase	the	dog	object-case	the	cat

'The dog is chasing the cat'

We can, however, construct a 'buggy' grammar rule which allows the object NP to attach to a transitive verb without this case marker. All we need to do is to specify that this rule is a rule not of ordinary Māori, but of a language just like Māori in every respect but for tolerance of this error. We then want to interpret the whole sentence as being 'in' this Māori-like language. To do this, we can use the same technique of undefined features and feature agreement as just described for proper names. First, we represent the value of the LANGUAGE feature not just as a simple label like ENGLISH or MAORI, but as something which is *itself* paramaterised for various features. Imagine that there are three different independent errors we wish to be able to pick up in Māori sentences. We can define the object MAORI as being further specified for three features, ERR1...ERR3, each of which can take the value YES or NO. The error rule we have already described could be defined as ERR1=YES, for instance. Grammatical rules which reflect 'correct' Māori are then represented as being *undefined* for all three subfeatures. However, the requirement for agreement between the LANGUAGE features of all the rules involved in a sentence will mean that it just takes one error in the sentence to propagate the YES feature for this error through the whole sentence. The upshot of this is that the system can simply examine the values of the error features of the top 'S' node in the sentence to work out what combination of errors has been made. And then it can respond with appropriate feedback.

CALL-specific mixed-initiative dialogue

As already mentioned in Section 3, mixed-initiative dialogue is a particularly good medium for L2 acquisition. Our system does not currently allow the tutor to take initiatives as a dialogue is proceeding. Accordingly, we plan to implement two new dialogue acts for the tutor which are specific to L2-learning dialogues.

In **teaching questions**, the tutor system has its own agenda of educational goals, to teach the student particular grammatical rules. When it is allowed to take an initiative, it will pursue these goals

by asking the student questions whose answers require understanding of, or use of, these grammatical rules. For example, say that the targetted rule is the rule which requires an object to be case-marked with *i*; a suitable question would be one whose answer is an ordinary transitive sentence in Māori. For instance:

System:	I whai te kurī kikorangi i tēhea makimaki? [Which monkey did the blue dog chase?]

In **feedback statements**, the tutor can respond to any utterance of the student's with comments about the language in which that utterance was expressed. A feedback statement can be positive, if the student's utterance was correct (in the relevant respect), or negative, if an error is diagnosed. In the latter case, the tutor rolls the dialogue back to the point when the student made their utterance, and prompts them to make it again. For instance:

System:	I whai te kurī kikorangi i tēhea makimaki? [Which monkey did the blue dog chase?]
User:	I whai te kurī te makimaki pōturi.
	[The dog chased the slow monkey. Sentence includes *i* mistake.]
System:	Remember that objects must be introduced with *i*! I whai te kurī kikorangi i tēhea makimaki?

We also plan to implement another kind of dialogue act for the student. In **meta-level questions**, a student can respond to any utterance of the tutor's with a 'meta-level' question about the language of that utterance, or about how to respond to the utterance in L2. A meta-level question initiates a **sub-dialogue**, similar in structure to utterances (f)–(h) in Figure 2. At the end of this sub-dialogue the student is obliged to respond to the tutor's original utterance. For instance:

System:	I whai te kurī kikorangi i tēhea makimaki? [Which monkey did the blue dog chase?]
User	What does "ngeru" mean?
System:	"Ngeru" means "cat".
User:	I whai te kurī i te makimaki pōturi.
	[The dog chased the slow monkey. No *i* mistake.]
System:	Ka pai! [Well done!]

6 Summary

In this paper, Sections 2 and 3 rehearsed some reasons for using natural language technology to promote indigenous languages, and specifically to teach such languages. Section 4 described the Te Kaitito system as it currently is, and Section 5 described a number of extensions which we are currently implmenting to adapt it to a CALL domain. We hope these extensions will further demonstrate the utility of language technology in these domains.

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