Kaitito: a system for sentence translation and dialogue-based language-learning

> Alistair Knott, Peter Vlugter Ian Bayard, Tori Weatherall

Dept of Computer Science/School of Māori Studies University of Otago



#### **Overview of the talk**

- Aims of the Kaitito project
- A sentence translation system for English and Māori
- A human-computer dialogue system as a Māori language teaching resource

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#### Aims of the Kaitito project

**Practical aim** To develop a suite of NLP resources for Māori

• A computational grammar of Māori

- A web-based Māori/English sentence translation system
- A computer-aided language learning system for Māori

#### Aims of the Kaitito project

#### Theoretical aim

To develop an architecture for integrating NLP resources.

- Grammar, sentence parser, sentence generator, lexicon
- Syntactic disambiguation, use of treebank corpora
- Error detection/correction, unknown word handling
- Semantic interpretation, discourse attachment
- Dialogue management (mixed-initiative, multi-speaker)

#### Aims of the Kaitito project

#### **Theoretical aim**

The architecture should exploit dependencies between these resources.

- Semantic interpretation/discourse attachment are useful for syntactic disambiguation. . .
- Utterance disambiguation is useful for error detection/correction...

• Treebanks are useful for unknown word handling. . .

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#### The syntax of Māori

Features of Māori (and other Polynesian languages):

- Predominantly VSO order
- Tense and aspect signalled lexically
- Few inflections (either on nouns or verbs)
- Null arguments
- Traces of ergativity (preponderance of passives)

# The syntax of Māori

A transitive sentence (active):

Kei te	whai	te	kurī	i	а	Hone
pres-progr	chase	the	dog	acc	pers.art	Hone
'The dog is	s chasin	g Ho	ne'			

#### A locative sentence:

Kei	te	whare	te	tangata
pres-loc	the	house	the	man
'The mai	n is ir	n the hc	ouse'	

### A bilingual grammar for sentence translation

Using LKB, we built a small bilingual grammar for English and Māori to support a sentence translator.

- The languages were kept separate with a LANGUAGE feature, which could take two different values.
- Agreement on this feature was enforced throughout the sentence.

#### A bilingual grammar for sentence translation

Some advantages of a bilingual grammar:

- Transparent support of bilinguality in the dialogue system (in particular for paraphrasing in another language)
- Potential support for dialects of Māori using a hierarchy of language types

The disadvantage is that it's hard to ensure sentences which translate each other have the same MRS.

# An example from the translation system

🌱 Te Kaitito, an Englis	ish/Mäori sentence translator - Mozilla	- O X
<u>File Edit View G</u> o	<u>B</u> ookmarks <u>T</u> ools <u>W</u> indow <u>H</u> elp	
Back Forward Relo	oad 👫 🕢 http://tutoko.otago.ac.nz:8080/lbin/teKaitito 🧹 🧟 Search 🧧	🔹 👻 🔟
🕺 🚮 Home 🛛 🦋 Bookmarks	🗶 Members 🧶 Web Mail 🧶 Connections 🧶 Biz Journal 🥒 SmartUpdate 🥒 Mktplace	
🗿 🥒 ISI Web of Knowle	edg 🚀 Full Text Electronic 🚀 7th SIGdial Worksho 🦨 Te Kaitito, an Englis 🚀 Diane J. Liti	man's Ho 🗙
	Welcome to Te Kaitito	Z
•	Please enter a sentence to translate	
the big dog who	o is chasing the cat barked	
	ä ë ï ö ü	
	CLEAR	
Here a	are some sample sentences that the system will translate.	
藩 🕮 🖋 🖾 🛛 Dor	he nui te tangata i roto i te whare kei te pao te tangata i ngä kurï i auau ai kei te auau te kurï i runga i te whare the cat chased the dog in the house kei te whai te kurï i te ngeru i roto i te whare	- <b>-</b> •
	Te Kaitito, an Engli Eile Edit View Go Back Forward Rel Home Bookmarks ISI Web of Knowle the big dog who Here	File Kalitto, an English/Maori sentence translator - Mozilla         Elle Edit View Go Bookmarks Tools Window Help         Back Found Reload       Imp://tutoko.otago.ac.nz.8000//bin/leKalitto         Home Bookmarks Members WebMail Connections BizJournal SmartUpdate Mktplace         Home Bookmarks Members WebMail Connections BizJournal SmartUpdate Mktplace         Isi Web of Knowledg       Full Text Electronic         Please enter a sentence to translate         Welcome to Te Kalitto, an Englis         Deare J Int         CLEAR         Here are some sample sentences that the system will translate.         he nui te tangata i roto i te whare         kei te pao te tangata i ngä kuri i auau ai         kei te auau te kuri i runga i te whare         the cat chased the dog in the house         Kei te whai te kuri i te nnemi i roto i te whare

# An example from the translation system



## **Overview of the talk**

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- A human-computer dialogue system as a Māori language teaching resource

Dialogue with a human tutor is a good medium for language learning.

- Students can practice the language in natural contexts.
- Students can ask the tutor questions.
- The tutor can ask the student questions.

Dialogue with a human tutor is a good medium for language learning.

• Students can practice the language in natural contexts.

- Students can ask the tutor questions.
- The tutor can ask the student questions.

So maybe an NL dialogue system can be useful as a language-learning tool.

A language-learning scenario has certain advantages as the domain for an NLP application.

- The user's grammar and lexicon in the target language will be small (at least at the beginning).
- The semantic content of language-learning dialogues can be pretty simple (at least at the beginning).

On the other hand, there are some challenges:

- The system must be tolerant to syntactic errors in the target language (and must in fact be able to diagnose and correct them).
- The dialogue structures supported by the system need to be quite complex.

#### System development methodology

Our CALL system is designed to accompany a university-level Māori language textbook.

- Chapters in the textbook introduce progressively more complex linguistic constructions.
- Each chapter begins with a dialogue illustrating the new constructions.

Our aim was to develop a system which could reproduce the first few of these dialogues.

# The first dialogueHoani:Hello, o friends.

Hoani:Hello, o friends.Hera:Hi, Hoani.

Hoani: Hello, o friends. Hera: Hi, Hoani. Piripi/Mere: Hello, Hoani.

Hoani: Hello, o friends.Hera: Hi, Hoani.Piripi/Mere: Hello, Hoani.Moana: Hello, respectable old man.

Hoani: Hello, o friends.
Hera: Hi, Hoani.
Piripi/Mere: Hello, Hoani.
Moana: Hello, respectable old man.
Hoani: How are you all?

Hoani: Hello, o friends.
Hera: Hi, Hoani.
Piripi/Mere: Hello, Hoani.
Moana: Hello, respectable old man.
Hoani: How are you all?
Piripi/Hera: Good.

Hoani: Hello, o friends.
Hera: Hi, Hoani.
Piripi/Mere: Hello, Hoani.
Moana: Hello, respectable old man.
Hoani: How are you all?
Piripi/Hera: Good.
Hoani: Who's your friend, o Hera?

Hoani:Hello, o friends.Hera:Hi, Hoani.Piripi/Mere:Hello, Hoani.Moana:Hello, respectable old man.Hoani:How are you all?Piripi/Hera:Good.Hoani:Who's your friend, o Hera?Hera:She's Moana.

Hello, o friends. Hoani: Hera: Hi, Hoani. Piripi/Mere: Hello, Hoani. Moana: Hello, respectable old man. How are you all? Hoani: Piripi/Hera: Good. Hoani: Who's your friend, o Hera? Hera: She's Moana. Hoani: Where are you from, o Moana?

Hello, o friends. Hoani: Hi, Hoani. Hera: Piripi/Mere: Hello, Hoani. Moana: Hello, respectable old man. How are you all? Hoani: Piripi/Hera: Good. Hoani: Who's your friend, o Hera? Hera: She's Moana. Hoani: Where are you from, o Moana?

#### **Overview of the CALL dialogue system**

The basic design: each lesson involves interacting with one or more different characters, who know different things, and who can initiate different tasks.

- Lesson sequencing: in each lesson, some new syntactic constructions are introduced.
- Lesson authoring: we want to make it possible for language teachers to create new characters and lessons themselves.

The basic interpretation-response loop The basic pathway involves **utterance interpretation**, followed by **response selection**.



#### **Grammar interface**

The dialogue system can operate with two LKB grammars:

- Our own Māori-English grammar (MEG)
- The English Resource Grammar (ERG).

To turn an MRS into an update (and back), two grammar-specific mappings are provided. (E.g. names of quantifier predicates, representation of message types)

### The format of an update

MRSs are converted into DRS-style representations comprising a nucleus and a set of presuppositions.

Presuppositions are resolved, and a dialogue act, speaker and hearer are assigned, to yield an **update**.

Here's an example update for *The dog chased a cat*:

Update:			
dialogue act: assert	message		x2 e1
speaker: ()		nucleus:	cat(x2) chase(e1,x1,x2) past(e1)
addressee. ()		presuppo	sitions: $\begin{pmatrix} 1 & 1 & 1 \\ 1 & 2 & - & - \\ 2 & dog(x1) & 1 \end{pmatrix}$
bindings: ((x1,))			

#### **Utterance disambiguation**

Syntactic disambiguation is done by 'look-ahead'.

 An update is computed for each syntactic parse, then the best of these is selected. (Preference for updates which don't involve accommodation, and that have the most resolved presuppositions.)

• As a side-effect of utterance selection, dispreferred parses are eliminated.

• Parse probabilities are used as a tie-break.

#### Statistical parsing

With the ERG, we use a simple statistical grammar derived from Redwoods.

We add a bias towards recently-used rules. Thus:

U: The patient authors lunch.
(TK's interpretation: [ The patient authors ][ lunch ] )

U: The doctor authors a report
U: The secretary authors a book
U: The patient authors lunch
(TK's interpretation: [ The patient ][ authors lunch ] )
**User modelling for syntactic disambiguation** With the Māori-English grammar (MEG), user modelling helps with syntactic disambiguation.

- Each lesson is associated with an **authoring dialogue**, which serves as a small treebank. (All of the author's sentences will have been disambiguated in this dialogue.)
- If a parse uses rules which do not occur in the authoring dialogue for the current lesson, or in those of preceding lessons, it is dispreferred.

### Syntactic clarification questions

Remaining ties are resolved by clarification questions presenting paraphrases for the user to choose between.

- U: I saw John at the office yesterday
- TK: Do you mean: (1) I saw John yesterday at the office (2) John at the office I saw yesterday
- U: Kei te kai te tangata
  TK: Do you mean:
   (1) The man is eating
   (2) The man is at the food

#### The dialogue model

Utterances execute dialogue acts.

- Forward-looking dialogue acts:
  - Assert: e.g. The dog chased a cat.
  - Query: e.g. What did the cat chase?
- Backward-looking dialogue acts:
  - Accept: e.g. Okay.
  - Answer: e.g. It chased a mouse.

A subdialogue is a forward and a backward-looking act.

#### The information state

There are two components to the information state:

- The **dialogue stack**: forward-looking dialogue acts before they have been responded to.
- The **common ground**: the set of facts which are jointly agreed on.

**Grounding**: when an assertion is acknowledged, it moves from the stack to the common ground.

### **Mixed-initiative dialogue**

When the stack is empty, either participant can go next.

- The system always gives the initiative to the user.
- The user can *concede* the initiative by hitting 'return'.
- At this point, the system makes an initiative of its own.



# Some example dialogue sequences

U:	Assert	Query	Query	-	-	-
	A dog barked	What barked?	What barked?	<return></return>	<return></return>	<return></return>
TK:	Accept	Answer	Answer	Query	Assert	Assert
	Okay	The dog	The dog	What barked?	A dog barked	A dog barked
U:	0	Accept	0	Answer	Accept	0
		Okay		The dog	Okay	
TK:		_		Accept	-	
				Okay		
U:		0		0	0	

# **Subdialogues**

If presupposition resolution fails, we generate a clarification subdialogue. For instance:

U:	Assert	
	The dog barked	
TK:	Clarify	
	Which dog barked?	
U:	Answer	
	The black dog.	
TK:	Accept	
	Okay	
U:	0	

### **Authoring mode**

Initiatives are selected from the system's private knowledge base, which is created previously by an 'author' or 'lesson planner'.

An authoring session is simply a special kind of dialogue.

Author:	Your name is Hone.
TK:	Okay.
Author:	You are from Dunedin
TK:	Okay.
Author:	Ask where I am from.
TK	Okay

### Authoring new lexical items

During authoring mode, any unknown words trigger a special word-authoring subdialogue.

The word-authoring algorithm consults a treebank to generate hypotheses about the type of the unknown word, and selects sets of sentences to progressively eliminate hypotheses until just one remains.

- A: The albatross is hungry.
- TK: I do not understand the word ALBATROSS. Which of these phrases illustrates its correct use? 1. the albatrosses of the projects are trustworthy

#### Authoring new lexical items

- 2. mr albatross browne is the manager
- 3. browne was hired on january albatross 1984
- 4. None
- A: 4
- TK: Is 'he showed her an albatross' a correct sentence?
- A: yes
- TK: What is the translation of 'the albatross eats' in Māori?
- A: ka kai te toroa
- TK: Is 'kua pai te toroa' a correct sentence?
- A: yes

#### The system's educational agenda

Each lesson is a dialogue with a collection of characters. The combined authoring dialogues for these characters form a mini-treebank.

- The syntactic constructions which appear in this treebank but not in treebanks for previous lessons define a **target construction set**: the educational objective for the lesson.
- During the lesson, we maintain an estimate of how well the student has assimilated each target construction.

### Student mode: initiative selection

During a lesson, the system characters have private knowledge of their own, so they can take initiatives.

Initiatives are chosen by generating a set of candidate initiatives, and evaluating each on two main criteria:

- Topic continuity (prefer to maintain current topic)
- Educational utility (prefer utterances which contain unassimilated target constructions).
- Initiatives can also be checking questions.

**Student mode: error diagnosis/correction** Error diagnosis/correction is closely integrated with the utterance disambiguation routine.

- To begin with, a set of **perturbations** of the student's original sentence is created.
- The perturbations are parsed, along with the original sentence. Updates are created for all successful parses.
- When selecting between updates, we give a preference to those from the original sentence.

#### **Creating perturbations**

There are two classes of perturbation.

- Character-level perturbations are the kind of perturbations modelled by spellcheckers. (However, our system assesses the likelihood of a typo by examining the interpretation resulting from a character-level perturbation.)
- Whole-word perturbations are particularly common in a language-learning scenario. Implementing these requires a database of correction pairs: for instance ((I like cook) (I like cooking))

#### **Correction subdialogues**

Corrections result from ungrammatical input and from grammatical input if a perturbation scores better.

- S: I am hapy.
- TK: You said: 'I am \*hapy\*'. But I think you mean: 'I am \*happy\*'. Please try again...
- S: There is a chef in the kitchen.
- TK: Okay.
- S: The chief is busy.
- TK: You said: 'The \*chief\* is busy'. But I think you mean: 'The \*chef\* is busy'. Please try again....

### **Multi-speaker dialogues**

One of the early topics to be learned in most languages is the system of personal pronouns (and often how this links to verb conjugations).

To provide a natural environment for practicing these topics, we have extended the system to be able to 'play' more than one character during a conversation.

• Some issues: addressee identification, private communication, group responses, partial answers. . .

### System design

- Autonomous characters: each keeps its own record of the common ground, and implements an (extended) version of the interpretation-response pipeline.
- An overarching **conversation manager** implements two basic loops: one over utterance interpretation, and one over response selection.
- In utterance interpretation, the parser runs only once, but each character creates their own updates.

Author: Add: Adam

Author: Add: Adam

Adam: Hello.

- Author: Add: Adam
- Adam: Hello.
- Author: Add: Eve

Author:	Add:	Adam
Adam:	Hell	э.
Author:	Add:	Eve
Eve:	Hell	о.

Author:	Add: Adam
Adam:	Hello.
Author:	Add: Eve
Eve:	Hello.
Author:	Adam, you live in London.

Author:	Add: Adam
Adam:	Hello.
Author:	Add: Eve
Eve:	Hello.
Author:	Adam, you live in London.
Adam:	Okay.

Author:	Add: Adam
Adam:	Hello.
Author:	Add: Eve
Eve:	Hello.
Author:	Adam, you live in London.
Adam:	Okay.
Author:	Your father is Jim.

Author:	Add: Adam
Adam:	Hello.
Author:	Add: Eve
Eve:	Hello.
Author:	Adam, you live in London.
Adam:	Okay.
Author:	Your father is Jim.
Adam:	Okay.

Author:	Add: Adam
Adam:	Hello.
Author:	Add: Eve
Eve:	Hello.
Author:	Adam, you live in London.
Adam:	Okay.
Author:	Your father is Jim.
Adam:	Okay.
Author:	Ask where I live.

Author:	Add: Adam
Adam:	Hello.
Author:	Add: Eve
Eve:	Hello.
Author:	Adam, you live in London.
Adam:	Okay.
Author:	Your father is Jim.
Adam:	Okay.
Author:	Ask where I live.
Adam:	Sure.

Author: Eve, you live in New York.

Author:

Eve:

Eve, you live in New York. What do you mean? (1) You live in New York City or (2) something else.

Author:Eve, you live in New York.Eve:What do you mean? (1) You live in New York<br/>City or (2) something else.

Author:

1

Author: Eve, you live in New York. Eve: What do you mean? (1) You live in New York City or (2) something else. Author: 1 Eve: Okay.

Author: Eve, you live in New York. Eve: What do you mean? (1) You live in New York City or (2) something else. Author: 1 Eve: Okay. Author: Adam's mother is Mary.

Author:	Eve, you live in New York.
Eve:	What do you mean? (1) You live in New York
	City or (2) something else.
Author:	1
Eve:	Okay.
Author:	Adam's mother is Mary.
Eve:	Okay.

Author:	Eve, you live in New York.
Eve:	What do you mean? (1) You live in New York
	City or (2) something else.
Author:	1
Eve:	Okay.
Author:	Adam's mother is Mary.
Eve:	Okay.
Author:	Adam and Eve, Eve's mother is Jane.
# **Authoring multiple characters**

Author: Eve, you live in New York. Eve: What do you mean? (1) You live in New York City or (2) something else. Author: 1 Eve: Okay. Author: Adam's mother is Mary. Eve: Okay. Author: Adam and Eve, Eve's mother is Jane. Adam/Eve: Okay.

## **Authoring multiple characters**

Author: Eve, you live in New York. What do you mean? (1) You live in New York Eve: City or (2) something else. Author: 1 Eve: Okay. Author: Adam's mother is Mary. Eve: Okay. Author: Adam and Eve, Eve's mother is Jane. Adam/Eve: Okay. Author: Eve's father is Bob.

# **Authoring multiple characters**

Author:	Eve, you live in New York.		
Eve:	What do you mean? (1) You live in New York		
	City or (2) something else.		
Author:	1		
Eve:	Okay.		
Author:	Adam's mother is Mary.		
Eve:	Okay.		
Author:	Adam and Eve, Eve's mother is Jane.		
Adam/Eve:	Okay.		
Author:	Eve's father is Bob.		
Adam/Eve:	Okay.		

User: Hello.

User: Hello.

Adam/Eve: Hello.

User: Hello.

Adam/Eve: Hello.

User: <return>

User: Hello.

Adam/Eve: Hello.

User: <return>

Adam: Where do you live?

- User: Hello.
- Adam/Eve: Hello.
- User: <return>
- Adam: Where do you live?
- User: I live in Dunedin.

- User: Hello.
- Adam/Eve: Hello.
- User: <return>
- Adam: Where do you live?
- User: I live in Dunedin.
- Adam: Okay.

- User: Hello.
- Adam/Eve: Hello.
- User: <return>
- Adam: Where do you live?
- User: I live in Dunedin.
- Adam: Okay.
- User: Eve, where do I live?

User:	Hello.
	110110

Adam/Eve: Hello.

User: <return>

- Adam: Where do you live?
- User: I live in Dunedin.

Adam: Okay.

- User: Eve, where do I live?
- Eve: You live in Dunedin.

User:	Hello.

Adam/Eve: Hello.

User: <return>

- Adam: Where do you live?
- User: I live in Dunedin.

Adam: Okay.

- User: Eve, where do I live?
- Eve: You live in Dunedin.
- User: <return>

User:	Hello.

Adam/Eve: Hello.

User: <return>

Adam: Where do you live?

User: I live in Dunedin.

Adam: Okay.

User: Eve, where do I live?

Eve: You live in Dunedin.

User: <return>

Eve: I live in New York.

User: Adam and Eve, who are Adam's parents?

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.
- Eve: Adam's mother is Mary.

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.
- Eve: Adam's mother is Mary.
- User: Who are Eves parents?

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.
- Eve: Adam's mother is Mary.
- User: Who are Eves parents?
- Eve: You said: 'Who are \*Eves\* parents?'. But I think you mean: 'Who are \*Eve's\* parents?'. Please try again.

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.
- Eve: Adam's mother is Mary.
- User: Who are Eves parents?
- Eve: You said: 'Who are \*Eves\* parents?'. But I think you mean: 'Who are \*Eve's\* parents?'. Please try again.
- User: Who are Eve's parents?

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.
- Eve: Adam's mother is Mary.
- User: Who are Eves parents?
- Eve: You said: 'Who are \*Eves\* parents?'. But I think you mean: 'Who are \*Eve's\* parents?'. Please try again.
- User: Who are Eve's parents?
- Eve: Well done. My mother is Jane. And my father is Bob

- User: Adam and Eve, who are Adam's parents?
- Adam: My father is Jim.
- Eve: Adam's mother is Mary.
- User: Who are Eves parents?
- Eve: You said: 'Who are \*Eves\* parents?'. But I think you mean: 'Who are \*Eve's\* parents?'. Please try again.
- User: Who are Eve's parents?
- Eve: Well done. My mother is Jane. And my father is Bob Adam: That's right.

User: <return>

- User: <return>
- Adam: Let's see if you remember: where does Eve live?

- User: <return>
- Adam: Let's see if you remember: where does Eve live?
- User: She lives in New York.

- User: <return>
- Adam: Let's see if you remember: where does Eve live?
- User: She lives in New York.
- Adam: That's right, well done.

# Future work: putting it all together

# Future work: putting it all together

The above dialogue is an example of 'wishful system integration'. Combining the different modules we have developed is likely to be very hard.

Some problems we anticipate:

• A distracting proliferation of clarification questions.

- A difficulty in parameter-setting.
- General system complexity issues.

# http://tutoko.otago.ac.nz:8080/teKaitito/

