Intelligent Computer-Assisted Language Learning

Part I: Individualized Feedback in Intelligent Tutoring Systems

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based on joint research with
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Real-life needs

- The time a student can spend with an instructor/tutor typically is very limited.
- In consequence, work on form and grammar is often deemphasized and confined to homework so that the time with the instructor can be used for communicative activities.
- The downside is that the learner has relatively few opportunities to gain awareness of forms and rules and receive individual feedback on errors.

Real-life needs

OSU practice confirming dilemma

A series of interviews with Spanish/Portuguese language instructors (cf., Amaral & Meurers 2005) finds that

- it can be difficult to achieve the communicative goal of an activity when students have problems using the appropriate language forms and sentence patterns.
- But class activities that focus on form or grammar patterns are perceived as problematic since
  - they reduce the pace of a lesson, and
  - individual differences make it impossible to have all students do the same tasks in exactly the same time.
- While instructors were very sceptical of CALL tools aiming to replace human interaction, they support tools
  - practicing receptive skills
  - reinforcing acquisition of forms
  - raising linguistic awareness in general

An opportunity for CALL

- The situation seems like an excellent opportunity for developing Computer-Assisted Language Learning (CALL) tools to
  - provide individual feedback on learner errors and
  - foster learner awareness of relevant language forms and categories.
- But existing CALL systems which offer exercises
  - typically are limited to uncontextualized multiple choice, point-and-click, or simple form filling, and
  - feedback usually is limited to yes/no or letter-by-letter matching of the string with a pre-stored answer.
    - Example: “Spanish Grammar Exercises” (B. K. Nelson)

Making CALL tools aware of language: NLP

- String matching is the most common technique used in CALL to analyze student input, which works well when
  - correct answers & potential errors are predictable & listable
  - there is no grammatical variation
  - envisaged errors correspond directly to intended feedback
- But what if
  - possible correct answers are predictable but not (conveniently) listable for a given activity
  - errors can occur throughout a recursively built structure
  - individualized feedback is desired which requires information about the learner input that can only be obtained through linguistic analysis

  $\Rightarrow$ Use NLP to analyze student input in such cases!

Aspects of Linguistic Modeling

- A range of potentially relevant aspects of linguistic analysis:
  - tokenization: identify words
  - morphological analysis: identify/interpret morphemes
  - syntactic analysis: identify selection, government and agreement relations and word order requirements
  - formal pragmatic analysis: identify coreference relations, information structure partitioning, ...
- Computational tools identifying such linguistic properties need to be integrated into CALL systems to obtain language-aware "Intelligent" CALL (ICALL).
- What architecture can the NLP analysis be integrated in?

  $\Rightarrow$ An Intelligent Tutoring System

Intelligent Tutoring Systems

- An Intelligent Tutoring System (ITS) is a computer program that intelligently interacts with the learner.
- An ITS should be able to:
  - accurately diagnose the knowledge structures and skills of the student
  - adapt instruction accordingly
  - provide personalized feedback
- Since Hartley & Sleeman (1973) an ITS is recognized as consisting of at least three components:
  - the expert model
  - the student model
  - the instruction model

Components of an ITS

- Expert Model:
  - the knowledge that the ITS has of its subject domain, in our case the linguistic knowledge
- Student Model (= Learner Model)
  - the component of the system keeping track of the student's current state of knowledge
  - It allows the ITS to infer the student's understanding of the subject matter and to adjust the feedback to the student's needs.
- Instruction Model:
  - the component that stores pedagogical information, how to conduct instruction
  - It helps define strategies to deliver appropriate feedback.

An example ITS: TAGARELA

- A concrete example for an ITS
  - provide opportunities for students to practice their listening, reading, and writing skills
  - provide individual feedback on learner input to system
  - foster learner awareness of language forms and categories

⇒ TAGARELA: Teaching Aid for Grammatical Awareness, Recognition and Enhancement of Linguistic Abilities

- An intelligent web-based workbook for beginning learners of Portuguese (Amaral & Meurers 2006, 2007a,b, 2008, 2009; Amaral 2007; Ziai 2009).
- Designed to satisfy the real-life FLT needs identified at OSU (Amaral & Meurers 2005)

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TAGARELA

System role, Activity types, Interface

- What role does the system play in teaching?
  → Self-guided activities accompanying teaching
- What type of activities are appropriate and useful for fostering awareness (and fit into the FLT approach)?
  → Activities ideally involve both form and meaning, such as listening/reading comprehension questions.
  - TAGARELA offers six types of activities:
    - listening comprehension
    - reading comprehension
    - picture description
    - fill-in-the-blank
    - rephrasing
    - vocabulary

  Similar to traditional workbook exercises, plus audio.
- What should the system interfaces look like?
  → Use L2 as far as possible (needs careful interface design).

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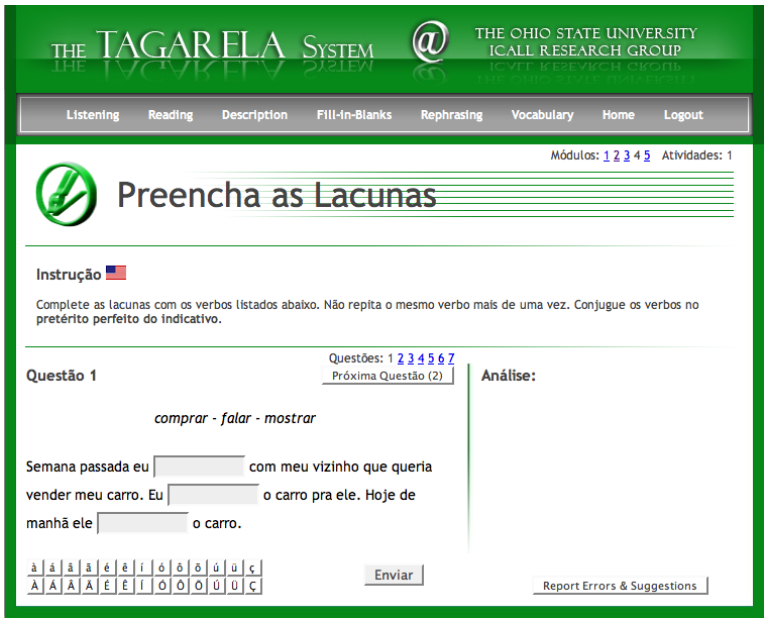

TAGARELA

Nature of the feedback

- Which forms of feedback are (most) successful in fostering awareness of forms/categories – and, ultimately, in influencing learning outcomes?
  - Meta-linguistic feedback, highlighting (cf. Heift 2004)
  - more research is needed into range of feedback types
    - what is appropriate for human-computer interaction/CMC (cf., e.g., Sachs & Suh 2007; **?**)

  including evaluation using
    - learning outcomes
    - online measures of noticing, e.g., using eye tracking, since no learning without noticing (Schmidt 1995)

TAGARELA

What to provide feedback on?

- What can/should feedback be provided on?
  - TAGARELA provides on-the-spot feedback on
    - orthographic errors (non-words, spacing, capitalization, punctuation)
    - syntactic errors (nominal and verbal agreement)
    - semantic errors (missing or extra concepts, word choice)
  - Providing feedback on meaning becomes crucial for activities such as reading and listening comprehension.
    - automatic meaning analysis can be effective → Lesson III

Feedback on Agreement

stões: 1 2 3 4 5 6 7 8
óxima Questão (3)

Análise:

Input: **Ela tens quinze anos.**

There is an agreement error in **person** between the **subject** and the **verb** in the sequence ***ela tens*** from your answer.

To see a possible answer, click here.

Enviar

Report Errors & Suggestions

THE TAGARELA System @ THE OHIO STATE UNIVERSITY ICALL RESEARCH GROUP

Listening Reading Description Fill-in-Blanks Rephrasing Vocabulary Home Logout

Módulos: 1 2 3 4 5 Atividades: 1 2

Leitura

Instrução

Leia o texto e responda às questões usando frases completas e o vocabulário apresentado no texto.

Quem é você?

Eu me chamo Patrícia Mattos, tenho quinze anos e moro em São Paulo. Eu estudo em uma escola pública e tenho muitos amigos.

Eu moro com minha mãe. Seu nome é Marta. Ela tem quarenta anos e é cozinheira em um restaurante de luxo.

Eu tenho um irmão. O nome dele é Claudio. Ele mora nos Estados Unidos e é músico. Ele toca Jazz e Blues. Ele é um excelente guitarrista.

Questões: 1 2 3 4 5 6 7 8

Questão 2 Próxima Questão (3)

Quantos anos ela tem?

Ela és quinze anos.

à á â ã é ê í ó ô õ ú ü ç
À Á Â Ã É Ê Í Ó Ô Õ Ú Ü Ç

Enviar

Análise:

Input: **Ela és quinze anos.**

I am not expecting the verb **ser** for this answer. Try using **ter** instead.

To see a possible answer, click here.

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Feedback on Word Choice

stões: 1 2 3 4 5 6 7 8
óxima Questão (3)

Análise:

Input: **Ela és quinze anos.**

I am not expecting the verb **ser** for this answer. Try using **ter** instead.

To see a possible answer, click here.

Enviar

Report Errors & Suggestions

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THE TAGARELA System @ THE OHIO STATE UNIVERSITY ICALL RESEARCH GROUP

Listening Reading Description Fill-in-Blanks Rephrasing Vocabulary Home Logout

Módulos: 1 2 3 4 5 Atividades: 1 2 3 4 5

Descrição

Instrução

Excreva uma frase completa usando a informação apresentada pela gravura e as palavras entre parênteses.

Questões: 1 2 3 4

Questão 1 Próxima Questão (2)

chamar-se - Ana e Beatriz

Elas se chamam Ana e Maria.

à á â ã é ê í ó ô õ ú ü ç
À Á Â Ã É Ê Í Ó Ô Õ Ú Ü Ç

Enviar

Análise:

Input: **Elas se chamam Ana e Maria.**

I think there is a problem with the proper noun you have chosen.

Are you sure you want to use **Maria** instead of **Beatriz**?

To see a possible answer, click here.

Report Errors & Suggestions

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Feedback on Wrong Word

Questões: 1 2 3 4

ma Questão (2)

e Beatriz

Análise:

Input: **Elas se chamam Ana e Maria.**

I think there is a problem with the proper noun you have chosen.

Are you sure you want to use **Maria** instead of **Beatriz**?

To see a possible answer, click here.

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Feedback on Missing Verb

Questões: 1 2 3 4 5

róxima Questão (4)

Enviar

Análise:

Input: **Qual o seu nome?**

Your answer is close, but there is a **verb** missing in your sentence.

To see a possible answer, click here.

Report Errors & Suggestions

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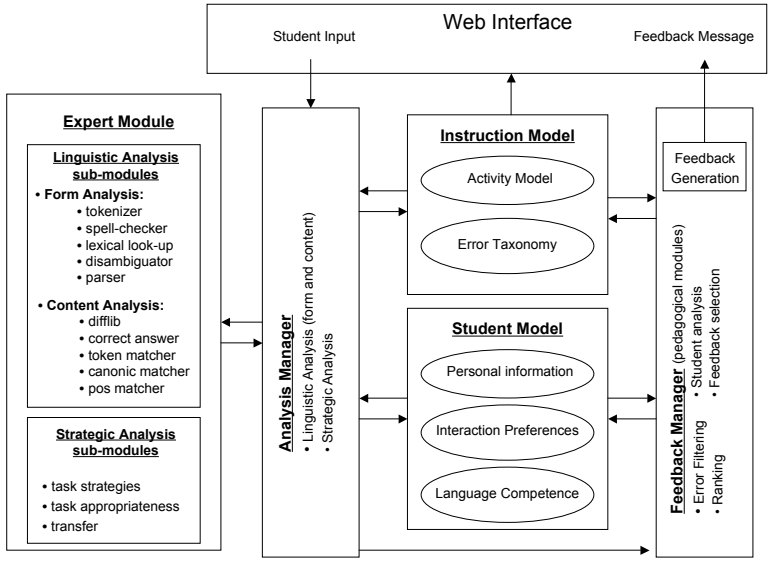
General Architecture of TAGARELA



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The three models

- The TAGARELA architecture includes
  - model of domain knowledge (linguistic knowledge)
  - student model
  - instruction/activity model
- What is the point of learner and activity models?

⇒ Providing feedback involves
- identifying linguistic properties of the learner input and
- interpreting them in terms of likely (mis)conceptions of the learner
  - This interpretation goes beyond linguistic form as such.
  - It needs to model the learner's use of language for a specific task in a specific context (Amaral & Meurers 2007a).
    → Lesson II on Learner Modeling

NLP analysis modules in TAGARELA

- Form Analysis:
  - tokenizer: takes into account specifics of Portuguese (cliticization, contractions, abbreviations)
  - lexical/morphological lookup: returns multiple analyses based on CURUPIRA lexicon (Martins et al. 2006)
  - disambiguator: finite state disambiguation rules narrow down lexical information, in the spirit of Constraint Grammar (Karlsson et al. 1995; Bick 2000, 2004)
  - parser: bottom-up chart parser establishes relations to check agreement, case and global well-formedness
- Content Analysis:
  - shallow semantic matching strategies between student answer and target, cf. Content Assessment Module (Bailey & Meurers 2006, 2008)
    → Lesson III on Content Assessment

How to plug it all together?

- Allow the analysis manager to flexibly employ NLP modules relevant to a particular activity.
- Flexible control also relevant from NLP perspective, to support interleaving of contributions from modules, e.g.:
  - part-of-speech ambiguity in Portuguese: *a* can be a
    - preposition (*to*)
    - pronoun (*her*, clitic direct object)
    - article (*the*, feminine singular)
    - abbreviation (*association*, *alcoholic*, etc.)
  - tokenization can resolve some part-of-speech ambiguities:
    - *da* = *de* + *a* (article)
    - *vê-la* = *ver* + *a* (clitic pronoun)
    - *à* = *a* (preposition) + *a* (article)
    - *A.A.A.* = *Associação dos Alcólicos Anônimos*

  → TAGARELA tokenizer annotates some part-of-speech

Annotation-based processing

- To support a flexible control structure, the data structures serving as input and as output for the analysis modules need to be uniform and explicit.
- NLP analysis = a process of enriching the learner input with annotations
  - parallel to XML-based corpus annotation → Lesson V
- The same data structure, the learner input annotated with information, is accessed throughout.
  - Closely related idea: Common Analysis System (CAS, Götz & Suhre 2004) of the Unstructured Information Management Architecture (UIMA).
  - UIMA-based reimplementation of TAGARELA's NLP (Ziai 2009)
- In addition to the information obtained by analyzing the input, we need information about the activity.

General Characteristics of Activities

Activities can be characterized and differ in:

- task specification
  - e.g.: listen, read, write, comment, complete
- level
  - e.g.: basic, intermediate, advanced
- expected input
  - e.g.: word, phrase, sentence
- nature and availability of target responses and type of variation from target that is permitted
- required skills and abilities, e.g.:
  - strategies needed (e.g., scanning, summarizing, grouping)
  - amount of content manipulation required
  - required awareness of linguistic categories and rules
- pedagogical goals behind activity and feedback provided:
  - generally: improve the required skills and abilities

Where it matters for processing

- General claim: The NLP analysis and feedback generation depend on the specific activity (type).
- The information from the activity model has an impact on
  - **Property Identification**:
    - Which linguistic properties (incl. errors) of the learner input can actually be observed in a given activity?
  - **Property Selection**: Which of the observed properties to select as likely error cause (or other relevant aspect)?
    - Which of the identified errors should be the focus of the feedback given activity and its specific pedagogical goals?
    - Which of the identified properties is most likely to provide a reliable assessment?
  - **Feedback Strategy**: Which strategy does it chose? E.g.:
    - explicit feedback on form for FIBs
    - scaffolding for reading comprehension (i.e., encouraging the use of required strategies)

Property identification in TAGARELA

- In TAGARELA, different activity types require different linguistic information to analyze student's input:
  - FIB: spell-checking, lexical information
  - Rephrasing: as above + syntactic processing and basic content assessment (correct answer, token matcher)
  - Reading: as above + all content analysis modules
- Why not always run everything?
  - "Don't guess what you know."
  - The more we know the linguistic properties, the types of variation, and the potential errors NLP needs to detect,
    - the more specific information we can diagnose
    - with higher reliability

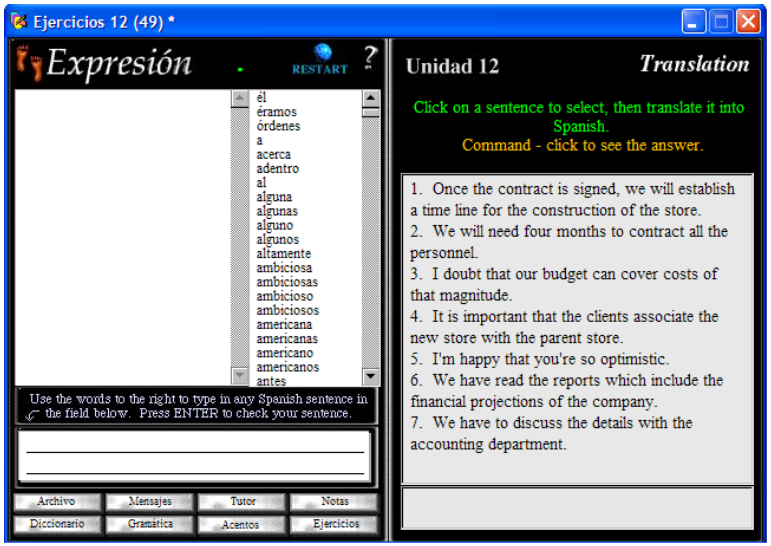
Challenge 1: Constraining Learner Input

The issue

- Processing completely free production input, allowing any number and type of errors, is not tractable.
- Systems must control/limit the type of input received.
- Current ICALL systems typically control input using outdated activity design: translation, dictation, etc.
  - Constraining activities in this way also circumvents need for semantic analysis of task appropriateness of input.
- Some consequences of this choice are:
  - limited number of activity types
  - decontextualized activities that do not fit communicative purposes (as used in current FLT)
  - lack of real-life data to evaluate and improve systems

Example: Decontextualized Translation Task

System “Spanish for Business Professionals” (Hagen 1999)



Challenge 1: Constraining Learner Input

Towards a solution

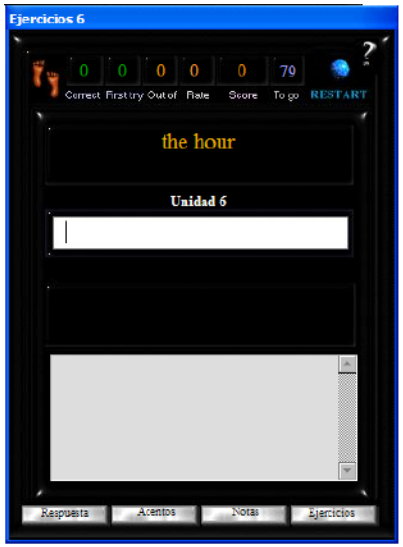
- How to control the input and be pedagogically sound?
  - Free vs. controlled input is a continuum, not a dichotomy.
  - Modify types of exercises so that they become communicatively significant.
  - Constrain form and content of input through communicative setup of the activity.
- The activity design and explicit learner models needed here serve double duty:
  - make activities and feedback pedagogically sound
  - constrain which language expressions and learner errors the NLP needs to be able to deal with.

Example:

- Vocabulary practice in Spanish for Business Professionals vs. in the TAGARELA system

Example: Vocabulary practice in *Spanish for BP*

- While *Spanish for BP* contextualizes activities with texts and audio, it only does so for multiple choice activities.
- Vocabulary practice:



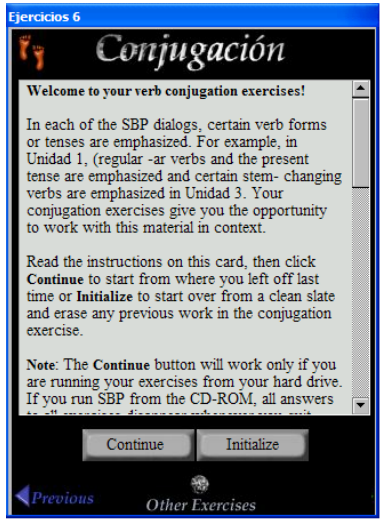
Example:

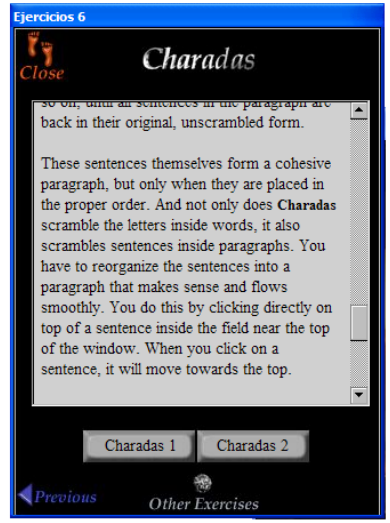
Challenge 2: Task specification (L1 vs. L2)

The issue

- ICALL systems rely heavily on L1 to provide instructions
  - Should L1 be avoided completely?
  - What is the right measure?
- Instructions used in ICALL systems often are
  - too long for students to actually read them
  - too complex to be given in L2.
- Interface design is typically not used to help students identify different exercise tasks.

Example: Long instructions in *Spanish for BP*





Challenge 2: Task specification (L1 vs. L2)

Towards a solution

How to provide instructions without or limiting the use of L1?

- Make activity types clear (list types of activities)
  - If exercise types are consistent, students experience with a given type of exercise can help avoid the problem.
- Use specific designs to indicate tasks
  - colors and icons identifying each activity type
  - page layout supporting task
- L1 can be used as a resource, but in a demand-driven way
  - provide buttons that allows students to look at
    - illustrating examples
    - instructions in L1

Example:

- Activity page design for the TAGARELA system

Example:

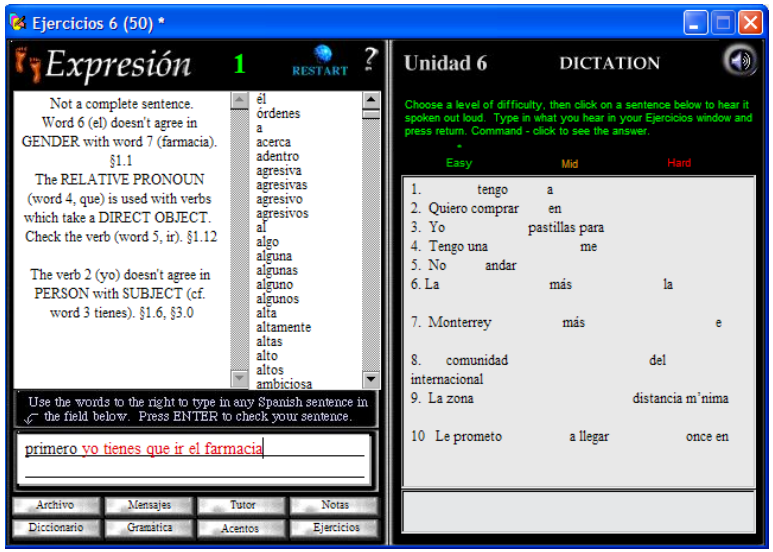
Example:

Challenge 3: Appropriate Feedback

The issue

- ICALL system design has made little use of SLA research on different types of feedback and their effectiveness. The systems
  - rely heavily on L1 to provide feedback,
  - mostly focus on explicit, meta-linguistic error feedback,
  - using linguistic terminology which students are not necessarily familiar with.
    - When should linguistic terminology be avoided?
    - When does it help?
    - Does it depend on the student?
- Most systems have no student model:
  - Feedback is only based on type of error.
  - No adaptation of feedback messages to student needs.

Example: Feedback in *Spanish for BP*



Challenge 3: Appropriate Feedback

Towards a solution

- The role of meta-linguistic feedback for student uptake in ICALL (Heift 2004)
  - Exploration limited to few, decontextualized exercise types.
- Integrate SLA research results on types of feedback and their effectiveness, e.g.:
  - Predominant role of noticing (cf., e.g., Robb et al. 1986)
  - Take developmental stages into account, e.g., feedback on agreement errors less effective for beginners (Pienemann 1984)
- The context influences the effectiveness of different types of feedback, so the transferability to the ICALL context needs to be tested (cf., e.g. Sagarra 2007).

⇒ Well defined learner and activity/instruction models can help us determine better feedback strategies.

TAGARELA meets real life language learners

- The system was used by beginning Portuguese students at The Ohio State University.
- Studying the system logs, we identified two aspects where feedback based on the linguistically correct analysis did not seem to be helpful for learners:
  - interpretation of tokens with accented characters
  - tokenization of compounds

Interpreting tokens: Accents (I)

Interpreting tokens: Accents (II)

Properties of Portuguese

Accents and their importance for lexical distinctions

- Accents in Portuguese encode important linguistic distinctions.
- Part-of-speech differences:
  - pronoun vs. verb
    - *esta* (this) – *está* (is)
  - conjunction vs. verb
    - *e* (and) – *é* (is)
  - verb vs. noun
    - *para* (stop) – *Pará* (state's name)
- Other differences:
  - gender
    - *avô* (grandfather) – *avó* (grandmother)
  - meaning
    - *coco* (coconut) – *cocô* (poop)

Mismatches in the interpretation of accents

- Learner Input: *O vaso esta em cima de mesa.*
- System's interpretation:
  - The word *esta* in the learner input is a determiner.
  - There is no form of the verb (*estar*) in the answer.
  - ⇒ The student did not include the main verb.
- Student's interpretation:
  - I included *esta* as a form of the verb *estar*.
    - (The correct spelling is *está*.)
  - There is a verb in the sentence.
  - ⇒ The lack of an accent is a spelling error.

Addressing the Interpretation of Accents

- Learners perceive the unaccented and accented versions of a character as orthographically similar and in consequence confuse linguistically unrelated forms.
- The system needs to capture the confusability of accented with unaccented characters.
  - Treat accented and unaccented characters parallel to common L1-transfer phonological confusions.
    - *está* and *esta* are confused just like
    - *liver* and *river* are by Japanese learners of English

⇒ Develop a module that compares whether different (un)accentuated variants of input words are more likely.
- Where this is the case, provide dedicated feedback alerting learner of this confusion.

Identifying tokens (I)

Regiões do Brasil

O Brasil está política e geograficamente dividido em cinco regiões. Os limites de cada região (Norte, Nordeste, Sudeste, Sul e Centro-Oeste) coincidem sempre com as fronteiras dos estados que as compõem.

A região Norte ocupa a maior parte do território brasileiro, com uma área que corresponde a 45,27% da área total do País. Formada por sete Estados, tem sua área quase totalmente dominada pela bacia do Rio Amazonas.

A região Nordeste pode ser considerada a mais heterogênea do País. Dividida em quatro grandes zonas - meio-norte, zona da mata, agreste e sertão -, ocupa 18,26% do território nacional e tem nove estados.

O Sudeste é formado por quatro Estados. Esta é a região de maior importância econômica do País, onde está concentrado também o maior índice populacional - 42,63% dos brasileiros.

Já o Sul, região mais fria do País, com ocorrências de geadas e neve, é a que apresenta menor área, ocupando 6,75% do território brasileiro e com apenas três Estados. Os rios que cortam sua área formam a bacia do Paraná em quase toda sua totalidade e são de grande importância para o País, principalmente pelo seu potencial hidrelétrico.

Finalmente, a região Centro-Oeste tem sua área dominada basicamente pelo Planalto Central Brasileiro e pode ser dividida em três porções: maciço goiano-mato-grossense, bacia de sedimentação do Paraná e as depressões. Ela é formada por quatro Estados e nela está a capital do Brasil.

Questões: 1 2 3 4 5 6 7
Próxima Questão (3)

Questão 2

Em que região fica o Rio Amazonas?

O Amazonas fica na região norte.

à á â ã é ê í ó ô õ ú ü ç
À Á Â Ã É Ê Í Ó Ô Õ Ú Ü Ç

Enviar

Análise:

Input: O Amazonas fica na região norte.

Excellent!

Identifying tokens (II)

Regiões do Brasil

O Brasil está política e geograficamente dividido em cinco regiões. Os limites de cada região (Norte, Nordeste, Sudeste, Sul e Centro-Oeste) coincidem sempre com as fronteiras dos estados que as compõem.

A região Norte ocupa a maior parte do território brasileiro, com uma área que corresponde a 45,27% da área total do País. Formada por sete Estados, tem sua área quase totalmente dominada pela bacia do Rio Amazonas.

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à á â ã é ê í ó ô õ ú ü ç
À Á Â Ã É Ê Í Ó Ô Õ Ú Ü Ç

Enviar

Análise:

Input: O Amazonas fica no região norte.

There is an agreement error in **gender** between the **determiner** and the **noun** in the sequence *o **região** norte* from your answer.

To see a possible answer, click here.

Properties of Portuguese

Tokenization

- Certain Portuguese words are syntactically complex.
- Contraction: preposition + determiner/pronoun
  - *no* = *em* (in) + *o* (the)
  - *nela* = *em* (in) + *ela* (it)
  - *destes* = *de* (of) + *estes* (these)
  - *às* = *a* (to) + *as* (the)
- Encliticization:
  - *comprá-lo* = *comprar* (to buy) + *o* (it)
  - *compram-nas* = *compram* (buy) + *as* (them)
  - *comprei-a* = *comprei* (bought) + *a* (it)

Mismatches in the identification of tokens

- Learner input: *O Amazonas fica no região norte.*
- System's interpretation: *no* = *em* + *o*
  - tokenized input: [em, o, região, norte]
  - syntactically analyzed: [$_{PP}$ em [$_{NP}$ o$_{masc}$, região$_{fem}$, norte]]

  ⇒ Agreement error between *o* and *região*.
- Student's interpretation:
  - There is no *o região norte* in the sentence I wrote.
  - I used the 'preposition' *no*.

  ⇒ So *no* seems to be the wrong preposition?

Addressing the Identification of Tokens

- The system needs to connect the surface form provided by the student with the system analysis of this input.
- An annotation-based NLP architecture (→ UIMA) readily supports this with multiple parallel layers of annotation for the learner input.
- The tokenization mismatch can be addressed by representing both surface and deep tokenizations of the learner input, and the mapping between the two.
  - Refer to surface form when generating the feedback.

Wrapping up: Token Identification & Interpretation

- In an ICALL system, problems can arise from mismatches between:
  - the identification and interpretation of the learner input by the system
  - how the learner perceives and conceptualize the input
- Where such mismatches arise, the feedback produced by the system is inadequate.
- We discussed two such mismatches for Portuguese tokens in TAGARELA:
  - interpretation of tokens: accented characters
  - identification of tokens: contraction, encliticization
- We argued that these problems can be addressed
  - by treating accented and unaccented characters parallel to common L1-transfer phonological confusions.
  - using an annotation-based NLP processing architecture supporting a rich representation of the learner input, including surface and deep tokenizations.

Conclusion

- Integration of computational, linguistic, and FLT/SLA expertise opens up opportunities for ICALL research
- ICALL Intelligent Tutoring Systems can address specific needs of real-life FLT:
  - provide opportunities for students to practice their listening, reading, and writing skills
  - provide individualized feedback to learner
  - foster learner awareness of language forms and categories
  - provide contextualized activities integrating meaning and form
- TAGARELA: its architecture and the relevance of its expert, learner, and activity models

→ learner modeling (Lesson II)

→ analyzing meaning (Lesson III)

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