TRIK: A talking and drawing robot for children with communication disabilities

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ABSTRACT
This paper describes an ongoing project where we develop and evaluate setup involving a communication board (e.g., for Blissymbolics or manual sign communication) and a drawing robot, which can communicate with each other via spoken language. The purpose is to help children with severe communication disabilities to learn language, language use and cooperation, in a playful and inspiring way. The communication board speaks and the robot is able to understand and talk back. This encourages the child to use the language and learn to cooperate to reach a common goal, which in this case is to get the robot to draw figures on a paper.

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augmentative and alternative communication, communication disabilities, children, robot, dialogue

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation (e.g., HCI): User Interfaces

INTRODUCTION

Dialogue systems

A dialogue system is a computer system which can communicate with people in a natural way; e.g., through spoken language. Until only a few years ago dialogue systems were relatively unusual in real life, but recently commercial alternatives have emerged which ordinary people can make use of. Existing systems include automatic customer services and interactive web agents. Several car companies have also presented new or future models which can interact in dialogue.

Most existing dialogue systems are meant to be used by competent language users without physical or cognitive language disabilities – either they are supposed to be spoken to (e.g., phone based systems), or you have to be able to type your questions (e.g., the interactive agents that can be found on the web). The few dialogue systems which are developed with disabled people in mind are targeted at persons with physical disabilities, which need help in performing common acts.

Dialogue systems have also been used for second language learning; i.e., learning a new language for already language competent people. Two examples are the artificial agent *"Ville – The Virtual Language Tutor"*, and *"SCILL – Spoken Conversational Interface for Language Learning"*, a system for practicing Mandarin Chinese.

However, we are not aware of any examples where a dialogue system has been used for improving first language learning, neither for persons with nor without disabilities.

Target audience

Our intended target group are children with severe communication disabilities, who needs help to learn and practice linguistic communication. One example can be children with autism spectrum disorders, having extensive difficulties with representational thinking and therefore will have problems in learning linguistic communication. Many children with autism are furthermore hindered in their speech development by the fact that they also have physical disabilities. Our dialogue system will give an opportunity to explore spoken language – content as well as expresson.

Another target audience which we believe will benefit from our system are children whose physical disabilities are very extensive, usually as a consequence of Cerebral Palsy (CP). The ablility to control a robot gives a fantastic opportunity to play, draw and express oneself in spoken language, which otherwise would be very difficult or even impossible.

Language development for children with disabilities

To be able to learn a language you must have practice in using it, especially in interplay with other language competent people. For the communication to be as natural as possible, all participants should use the same language. For that reason there is a point in being able to express yourself in spoken language, even if you do not have the physical or cognitive ability. If you usually express yourself by pointing at a communication board, it is thus important that the board can express in words what you say by pointing. This is even more important when you are learning a language, and its expressions and conventions [5, 8, 9].

When it comes to children with autism, learning appears to be simpler in cooperation with a technical product (e.g., a computer), since the interaction in that case is not as complex as with another human [1]. Autistic persons have difficulties in coordinating impressions from several different senses and different focuses of attention. When you are expected to listen to, look at and interpret a number of small signals, all at the same time, such as facial expressions and gazes, human communication can become very difficult.

All children need repetition to learn things. Children with disabilities often need even more repetition in their language learning, because of their lack of communicative functions and in their ability to automatise. Adapted techniques, and in this case the speech-controlled drawing robot, can offer the required repetition as an exciting complement to human communication.

PROJECT DESCRIPTION

Our basic idea is to use a dialogue system to support language development for children with severe communicative disabilities. There are already Bliss Boards connected to speech synthesis in the form of communication software on computers. The main values that this project add to existing systems are

1. that the child can explore language on her own and in stimulating cooperation with the robot;
2. that it can be relieving and stimulating at the same time, with a common focus on the dialogue together with a robot; and
3. that the child is offered an exciting, creative and fun activity.

By being able to use a picture- or symbol-based communication board the children are given an exciting opportunity to explore language; to play and in the same time learn to use a method for alternative and augmentative communication.

A talking communication board and a talking robot

In our goal scenario the child has a communication board which can talk; i.e., when the child points at some symbols they are translated to an utterance which the board expresses via speech synthesis, and in grammatically correct Swedish. This is recognized by a robot which can move around on a paper and draw at the same time. The robot executes the commands that was expressed by the communication board; e.g., if the child points at the symbol for *"change crayon"* and the colour *"red"*, the utterance might be *"change to the red crayon"*, which the robot then performs.

The picture above describes another possibility – when the robot is given too little information. E.g., if the child only points at the symbol for *"change crayon"*, the robot does not get enough information. This is noticed by the dialogue system and the robot asks a follow-up question, such as *"what color do you want to change to?"*. Now the child can answer by pointing att *"red"*, which is then uttered by the communication board.

Functionality of the robot

The robot we have in mind is a variant of the LOGO-robot which was developed at Massachusetts Institute of Technology for learning children to use computers and program simple applications [6]:

The robot has a set of pens or crayons of different colours, which it can switch between. It can lift the pen (for not drawing) or lower it (for drawing). It can move forward and backward, and turn right and left. The robot can also be programmed to execute command sequences; e.g., it is possible to define that a *"square"* is to first move forward, turn left 90 degrees, and then redo the same thing three more times.

Pedagogical advantages

By having the communication board and the robot talking to each other there is a possibility for users in an early stage of language development to understand and learn basic linguistic principles. For the linguistically more advanced child the robot offers the possibility of understanding basic properties of dialogue such as turn-taking, asking and answering questions, the importance of providing sufficient information, and cooperating to achieve a shared goal. In addition, the child learns to plan its actions in order to achieve a goal; e.g., getting the robot to draw a flower.

At yet more advanced stages, the child may learn simple "programming" to get the robot to repeatedly perform a complex action. For example, the child may provide a step-by-step instruction for drawing a square, and then name this shape *"square"*. Subsequently, the robot can be told to draw new squares using a single command (*"draw a square"*). This provides further practice in using dialogue to achieve more complex goals.

On a technical level, the setup works without the robot and the communication board actually listening to each others' speech. Instead, they communicate using a wireless electronic communication protocol (see the section about "Perfect speech recognition" below). However, there is an important pedagogical point in having them (apparently) communicate using spoken language. It provides the child with an experience of participating in a spoken dialogue, even though the child does not speak.

Generality of the approach

One reason for choosing a drawing robot is that is provides a simple yet infinitely variable arena of behaviour. A further reason is that no advanced sensors ort motors are needed to build such a robot. An alternative which is equally understandable and useful to the user could be a robot building towers using wooden blocks, but in this case the robot would need to be more advanced and difficult to construct.

This does not mean that the technique cannot be applied to other domains. There is nothing about the idea itself – a talking communication board communicating with a robot via a dialogue system – which dictates what the robot can be used for. To adapt the setup to a new domain, one needs to specify the relevant domain knowledge to the GoDiS dialogue system, and perhaps provide new signs for the communication board which are appropriate to the new domain.

IMPLEMENTATION

This section describes some technical aspects of the implementation the TRIK system.

Components

The final TRIK setup will consist of the following components:

- a simple LEGO robot with a set of coloured pencils and the ability to turn and move in all directions;
- a communication board with pictograms/symbols; and
- a laptop computer with a dialogue system and speech synthesis, which is physically attached to the communication board and communicates wirelessly with the robot.

The laptop will seem like it is a part of the communication board, but it will also control the robot, both movements and speech. Every utterance by the robot will be executed by the speech synthesizer on the laptop, and then sent to the robot via radio.

Perfect speech recognition

Typically, the most error-prone component of a spoken dialogue system is speech recognition; i.e., the component responsible for correctly interpreting speech. This of course becomes even more problematic when working with language learning or communication disorders, since in these sitations it is both more difficult and more important that the computer correctly hears and understands the user's utterances. An advantage of the TRIK setup is that we will, in a sense, have "perfect speech recognition", since we are cheating a bit. The robot does not actually have to listen for the speech generated by the communication board; since the information is already electronically encoded, it can instead be transferred wirelessly. This means that the robot will never hear *"go forward and then stop"* when the user actually says *"go forward seven steps"*.

Existing resources

This section describes the technical resources which will be used in TRIK.

The GoDiS dialogue manager

A dialogue system typically consists of several components: speech recognizer, natural language interpreter, dialogue manager, language generator, speech synthesizer and a short-term memory for keeping track of the dialogue state. One can make a distinction between dialogue *systems*, which (ideally) are general and reusable over several domains, and dialogue system *applications*, which are specific to a certain domain. The dialogue manager is the "intelligence" of the system, keeping track of what have been said so far and deciding what should be said next.

The GoDiS dialogue manager [2] has been developed at the Department of linguistics at the University of Gothenburg over several years. It has been designed to be easily adaptable to new domains, but nevertheless be able to handle a variety of simpler or more complex dialogues. For example, GoDiS can either take initiative and prompt a user for information, or take a back seat and let the experienced user provide information in any desired order, without having to wait for the right question from the system.

The grammar formalism GF

The GF grammar system [4, 7], developed at the Deparment of Computer Science at the University of Gothebburg, makes it easy to quickly design the language interpretation and generation components of a dialogue system. Inaddition, GF is a multilingual formalism, which means that it is well suited for use in translation between different languages. Since, e.g., the graphical Blissymbolics system can be regarded as a language in itself, it is possible to write GF grammars for translating between symbols and spoken Swedish [3].

LEGO Mindstorms

We intend to build the robot itself using LEGO Mindstorms, a kind of technical lego which can be controlled and programmed via a computer. Apart from being cheap, this technology makes it easy to build a prototype and to modify it during the course of the project.

EVALUATION

When the system has been completed, it will be evaluated by a number of users with linguistic communication disorders.

Design

The evalation process is designed as a case study with data being collected before and after interventions. The children will also be video recorded when playing with the robot, to enable analysis of common interaction patterns.

Users

The users will consist of children with a diagnose within the autism spectrum, and children with a CP diagnosis. The chronological age of the children may vary but the intention is to both include children in an early stage of language development, and children who have developed further and where there is a need to develop and train grammatical skills.

Evaluation method

After the children's families and/or personnel have been instructed about the use of the robot, they will be allowed to try using it in their home or pre-school during 3 to 4 months. The goal is that the children should have the opportunity to play with the robot at least 3 or 4 times per week.

Before the robot is used, the parents answer a survey about how they perceive their interaction with their children. The will also estimate the communicative abilities of their children. The surveys will be complemented with questions based on the vocabulary which will be included in the children's communication boards. When the trial period is over, the surveys are repeated. During the trial period, the children will be filmed twice while using the robot, in the beginning and towards the end. The videos will then be analysed using suitable methods, such as Activity-Based Communication Analysis, developed at the Department of Linguistics at the University of Gothenburg.

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