Language Learning & Technology October 2012, Volume 16, Number 3
http://llt.msu.edu/issues/october2012/emerging.pdf pp. 1–9

EMERGING TECHNOLOGIES
ROBOT ASSISTED LANGUAGE LEARNING

Jeonghye Han, Cheongju National University of Education

Along with the rapid development of information and communication technologies, educators are trying to keep up with the dramatic changes in our electronic environment. These days mobile technology, with popular devices such as iPhones, Android phones, and iPads, is steering our learning environment towards increasingly focusing on mobile learning or *m-Learning*. Currently, most interfaces employ keyboards, mouse or touch technology, but some emerging input-interfaces use voice- or marker-based gesture recognition. In the future, one of the cutting-edge technologies likely to be used is robotics. Robots are already being used in some classrooms and are receiving an increasing level of attention. Robots today are developed for special purposes, quite similar to personal computers in their early days. However, in the future, when mass production lowers prices, robots will bring about big changes in our society. In this column, the author focuses on *educational service robots*. Educational service robots for language learning and *robot-assisted language learning* (RALL) will be introduced, and the hardware and software platforms for RALL will be explored, as well as implications for future research.

ROBOTS: ANTHROPOMORPHISM OF THE MEDIA

We have seen the evolution of various media, from the one-way mass media TV, to computers with enhanced interactivity and personalized services. With the proliferation of computers, computer-aided instruction (CAI) has been in the limelight in various instructional design theories since the 1970s. The advent of the World Wide Web and Internet has changed CAI into web-based instruction, and with the extensive use of mobile devices and tablet PCs, various language-learning applications based on m-Learning are emerging in the market (Godwin-Jones, 2011).

Since the mid-2000s, anthropomorphized robots in various forms have been developed, with faces, arms, and mobile devices or tablet interfaces attached to their chests, as shown in Figure 1. These robots are a type of anthropomorphized media, merging mobile information technology (IT) and robotics.

Figure 1. IROBIQ, from http://www.irobibiz.com/.

These robots not only have a tablet interface but are also capable of autonomous movement, visual recognition through a camera, voice recognition through a microphone, and physical interaction based on various sensors, such as a touch sensor, infrared sensor, ultrasonic sensor, bumper sensor, or floor detection sensor. Computers or mobile devices also can be said to be capable of nonverbal communication employing cyber characters or videos. However, robots are notable in their capacity for nonverbal communication, such as facial expressions, gestures and actions, while coexisting with users in a real environment, such as the home or the classroom. Also, robots are different from computers and mobile devices in that they have a friendly appearance, a name, a birth story, a personality, and are capable of social relations. Moreover, robots with a computer display on their body can provide mobile services just the same as computer and mobile devices.

EDUCATIONAL SERVICE ROBOTS

There are mainly two types of educational robots: hands-on robots, such as LEGO MINDSTORM, and educational service robots, which are intelligent robots deployed into learning environments. The foremost purpose of hands-on robots is to promote interest and enhance creativity in STEM (science, technology, engineering and mathematics) education. It is argued that educational service robots, with their friendly appearance and physical movements, can establish interactive relationships with learners, particularly with children, making learning more pleasurable by increasing learners' interest and lowering their affective filters (Han, 2010). The focus of this paper is educational service robots, which are primarily employed in the teaching of a second/foreign language at preschools, primary schools, and so on.

Educational service robots as intelligent media in the teaching and learning environment are divided into three categories: the *tele-operated type*, *autonomous type,* and *transformed type,* according to the location of their intelligence. The tele-operated type provides the tele-presence of educational services through a remote control the instructor uses; the autonomous type has its own artificial intelligence; and, the transformed type has both tele-operation and autonomous control, and can switch between the two (Han, 2010). Figure 2 shows a representative example for each category: VGO, ROBOVIE, and ROBOSEM, which are tele-operated, autonomous, and transformed, respectively.

Figure 2. VGO (left), ROBOVIE (center) and ROBOSEM (right).

Educational service robots have started to appear in Canada, Japan, South Korea, Taiwan, and the United States. To take a closer look at the use of educational robots in each case, there are: Canada's PEBBLES (Fels & Weiss, 2001); Japan's ROBOVIE (Kanda, Hirano, Eaton, & Ishiguro, 2004) as a peer tutor for elementary English, PAPERO (NEC, 2004) for child-care, Keepon (Beatbots, 2007) as an interaction inducer for autistic children, and Saya (Shuster, 2010) for use in Japanese preschools; South Korea's preschool teaching assistant, IROBI (Han, Jo, Kim, & Park, 2005), IROBIQ (Hyun, Kim, Jang, & Park, 2008), primary school English teaching ROTI and ENGKEY (Yonhapnews, 2009), and primary school English teaching assistant, ROBOSEM (Park, Han, Kang, & Shin, 2011); Taiwan's elementary English teaching assistant ROBOSAPIEN (You, Shen, Chang, Liu, & Chen, 2006); and, the United States' preschool peer tutor, RUBI and QURIO (Movellan, Tanaka, Fortenberry, & Aisaka, 2005; Movellan, Eckhardt, Virnes, & Rodriguez, 2009), and VGO (Vgo communications, 2011) for young patients.

Educational service robot hardware platforms

Table 1 shows a brief description of the hardware platforms for the major education service robots.

Table 1. *Specifications of some educational service robots*

Type	Name	Country	Role	Height (cm)	Facial emotion	Moving parts	Touch sensor	Serving visual material	Server
Tele-presence	ENKEY	S. Korea	native speaker	100	operator	none	none	√	N/A
	GIRAFFE	USA	student	137-176	operator	head	none	none	N/A
	PEBBLES	Canada	student	N/A	operator	hand	N/A	none	N/A
	ROBOSAPIEN	USA	native speaker	38	none	head, arms	6	none	none
	ROTI	S. Korea	native speaker	122	operator	head	none	√	none
	VGO	USA	student	122	operator	none	none	none	N/A
Auto-nomous	KEEPON	Japan	peer	25	none	body	none	none	none
	PAPERO	Japan	peer tutor	38	robot's own	head	9	none	√
	ROBOVIE	Japan	peer tutor	30-91	none	head, arms	11	none	√
	SAYA	Japan	teacher	N/A	robot's own	head, arms	N/A	none	none
Trans-formed	IROBIQ	S. Korea	teaching assistant	45	robot's own	head, arms	6	√	√
	ROBOSEM	S. Korea	native speaker, teaching assistant	110	robot's own	head, arms	5	√	√
	TIRO	S. Korea	teaching assistant	110	robot's own	head, arms	none	√	√

Note. N/A = no information from the website or papers.

Most tele-presence robots in Table 1 feature a simple Wi-Fi video conferencing function and remote controlled movements. Also, to cater to the convenience of the remote controller, these robots are usually equipped with compulsory wheels for travel, but have no arm or head movement. They are mostly developed at a low-cost. Tele-presence robots are predominantly used by native speakers or English teachers, and the interaction is comparatively limited since they only offer video conferencing and limited mobility. They can, however, sustain long-term interaction, but when there is a breakdown in the network, all interactions stop.

The autonomous robots in Table 1 feature complex body and arm movement, but they are quite expensive for the general market and mostly used for research. Also, for the robots to interact autonomously, they need preprogrammed scenarios. With current artificial intelligence technology, however, seamless interaction is unattainable, thus the novelty effect can wear off quickly. Still, the advantage is that interaction is possible regardless of network problems.

In the case of the transformed type of robots in Table 1, these robots have been developed to perform an assisting role rather than to interact autonomously. The teacher can control the robots by remote control or voice recognition, and when they are in tele-operated mode, a native speaker can control them. If network problems occur during the tele-operated mode, they can swiftly be switched to the autonomous mode. Hence interaction is always possible regardless of network stability, and continuous interaction is supported.

Educational service robot software platforms

Most operating systems for intelligent robots are based on MS Windows and Linux. Since the majority of robot companies own unique robot hardware and exclusive software platforms, developing robot applications is difficult. This has decelerated the popularization of robots and the opening up of robot markets. To address this predicament, the worldwide movement towards developing an integrated software platform started in earnest in 2000. Since then, many countries have developed their own robotic software platform with slightly different characteristics, such as Microsoft Robotics Developer Studio (Microsoft RDS), Willow Garage's ROS (Robot Operating System), the EU's RT CORBA-based standard platform OROCOS (The Open Robot Control Software), Japan's National Institute of Advanced Industrial Science and Technology (AIST) driven RT middleware, and Korea's OPRoS (Open Platform for Robotic Service), and so on.

MS RDS is software oriented towards developers who are restricted to developing robot applications using preset robot hardware. In 2010, Willow Garage provided open source robotic software called ROS. ROS is engaged with a community of one hundred thousand robot developers worldwide, and from this foundation, various robot applications can be programmed, leading to the effective promotion and expansion of robot proliferation (http://www.ros.org). Recently, Willow Garage has received attention for having integrated their software with the Smartphone OS Android.

These robot software platforms enable programmers to develop various applications so that robots can perform multiple functions. By integrating a robot's modular features, such as voice- and sound-recognition, face-detection and recognition, gesture- and object-recognition, synthetic speech, driving, space recognition, and position recognition, these software platforms enable the robot to provide various services. For example, in an instance of RALL service, the robot can easily look at a learner who is calling its name and move to a corresponding location. Most robots shown in Table 1 have their own robot software platforms. Efforts are being made, however, to integrate these robots to an open platform, such as ROS, and soon, when standardization is realized, the robot service market will rapidly expand.

ROBOT ASSISTED LANGUAGE LEARNING (RALL)

Currently, in most countries in Asia where English is taught as a foreign language, various instructional methods are being used. These include collaboration with native speakers, demonstrating and diagnosing pronunciation using computer- or mobile-based applications, video conferencing with native speakers, one-on-one native speaker tutoring, and so forth (see Figure 3). In language education, direct interaction with native speakers is considered the most effective way of instruction. However, when it is difficult to employ native speakers, teachers can always utilize computer- or mobile-based applications. Yet, due to limitations in current image recognition technology, most applications based on computers or mobiles focus on voice-based verbal messages.

As an alternative, video conferencing with native speakers can be considered. Video conferencing can be effective in demonstrating pronunciation. However, this is not popular because there are still limitations in pronunciation diagnosis since the native speaker needs to be close to individual pupils or the classroom as a whole. Recently, some after-schools programs in Korea have been conducting one-on-one native speaker tutoring. It is true that the educational benefits of individualized interaction are substantial, but there also are several drawbacks: it is costly for learners; when miscommunications occur there is no help available in the learner's mother tongue; and, finally, different native speakers may be assigned to different classes according to their schedules and this would impede learners' progress-tracking.

Figure 3. A traditional collaborative class, a video conferencing class, and a one-on-one conference in Korea.

Among the various instructional models in language learning, we should consider RALL, employing currently emerging robot technology. This anthropomorphized version of existing mobile devices is autonomous, with features such as image recognition through camera, voice recognition through microphone, and interaction based on various sensors. Robot-assisted learning (RAL) can be defined as learning assisted by robots with such features (Han, 2010). In the domain of RAL, RALL can be defined as targeting language learning in particular. Most robots in RALL are interlinked with instructional material, and can perform the role of the native speaker to interact with learners. The following scenes in Figure 4 show English classes being conducted with IROBIQ and ROBOSEM.

Figure 4. RALL with IROBIQ (left) & RALL with ROBOSEM (right from Park, Han, Kang & Shin, 2011).

RALL shares the merits of the conventional collaboration model—the face-to-face, physical interaction with native speakers—but it is easier to recruit native speakers for tele-conferencing. Furthermore, RALL also has the advantage of an instruction model employing applications, by sharing instructional material over a TV or display device, such as a projector beam. Class activities, such as English chanting, can be recorded. Using radio frequency identification (RFID) tags, individual progress can be logged and tracked. Figure 5 shows a sample of a RALL lesson plan. When compared to common computer-assisted language learning (CALL) classes, robots need to be programmed to interact with the teacher and pupils.

<table>
<tr><td colspan="2">Grade</td><td colspan="2">3rd grade students on a Korean elementary school</td><td>Period</td><td>Formal learning</td></tr>
<tr><td colspan="2">Unit</td><td colspan="4">4. Happy birthday! (3/3)</td></tr>
<tr><td colspan="2">Theme</td><td colspan="4">Celebrating birthday, expressing thanks</td></tr>
<tr><td colspan="2">The purpose of the lesson</td><td colspan="4">The students are able to express birthday greetings and thanks.
The students are able to give and receive presents (cards) with birthday greetings.
The students are able to make conversation, using expression of birthday greetings and thanks.</td></tr>
<tr><td colspan="2">Materials</td><td colspan="4">ROBOSEM, Gift-picture cards, Bracelet RFID tag</td></tr>
<tr><td colspan="2">Treatment time</td><td colspan="4">40 minutes</td></tr>
<tr><td>STEP</td><td>PROCEDURE</td><td>ROBOT CONTROL</td><td colspan="2">TEACHING & LEARNING ACTIVITIES</td><td>TIME</td></tr>
<tr><td rowspan="8">Intro-duction</td><td rowspan="8">Greeting</td><td rowspan="4">Recognition of voice localization</td><td colspan="2">Teacher: Good morning everyone.</td><td rowspan="8">3 mins</td></tr>
<tr><td colspan="2">Students: Good morning teacher, Kim.</td></tr>
<tr><td colspan="2">Teacher: Let's ask ROBOSEM together, ‘How are you?’</td></tr>
<tr><td colspan="2">Students: How are you?</td></tr>
<tr><td>Voice recognition</td><td colspan="2">ROBOSEM: I'm good. I'm excited today because today is my birthday.</td></tr>
<tr><td>Recognition of voice localization</td><td colspan="2">Teacher: I've heard that today is your birthday, ROBOSEM. Boys and girls, let's say happy birthday to langbot.</td></tr>
<tr><td>Voice recognition</td><td colspan="2">Students: Happy birthday ROBOSEM!</td></tr>
</table>

Figure 5. A part of a RALL lesson plan using ROBOSEM.

RELATED WORK ON RALL

Research and development of RALL started around 2004, mainly in countries like Japan, Korea, and Taiwan, where English is taught as a foreign language. Japan’s ATR research international institute conducted research on student motivation during recess in elementary schools with ROBOVIE, a robot that remembers around 300 English sentences, simple everyday expressions, and recognizes 50 words (Kanda, Hirano, Eaton, & Ishiguro, 2004). In March 2004, Korean developer Yujin Robot announced a home robot IROBI, loaded with services such as reading English, photo books, and English chanting (Han, Jo, Park, & Kim, 2005). Han et al. (2005) studied learners’ achievements with IROBI—the precursor to IROBIQ—in English learning compared to computers, and the results showed IROBI to be more effective. In Han and Kim (2006), through a Delphi survey of elementary school teachers who have information technology literacy, it was found that RAL instruction is considered most appropriate for subjects such as English, Korean, and music, and was rated as excellent for language learning. In Taiwan, You, Shen, Chang, Liu, and Chen (2006) applied ROBOSAPIEN, an Infrared remote controllable toy-like robot manufactured by WowWee Toys, to an English classroom with five instruction models. In their study of preschoolers over a four-week period, Hyun, Kim, Jang, and Park (2008) showed a robot’s media effectiveness over computers in preschoolers’ story building, vocabulary, understanding, and word recognition in Korean reading activities. The RUBI/QRIO project (Movellan et al., 2005) suggested that English vocabulary learning efficiency was higher among preschoolers when they employed RUBI compared to computers (Movellan et al., 2009).

Meanwhile, Han and Kim (2009) introduced various service types provided by the robot TIRO in elementary school classes, and ranked the favorites. The results suggested that among TIRO’s services, the ones that enhanced the relationship between children and the robot in English class were preferred.

The most popular service was TIRO's praising and cheering, followed by face-to-face conversation and role-play with TIRO. Han (2010), based on previous studies, found that in Japan and the United States, robots are mostly given the role of a peer tutor, while in Korea, they are given the role of a teaching assistant and friend. Japanese robots provide service focusing on voice- and gesture-based interaction, while Korean and American robots base their service on visual instruction materials, such as Flash contents. It was also concluded that the subjects most suitable for RAL would be language learning, such as in English education, where robots are effective in inducing motivation and enhancing achievement, synchronizing visual contents with instruction, and playing the teaching assistant role necessary for long-term interaction. Park, Han, Kang, and Shin (2011) designed class materials to evoke children's motivation, to sustain their interaction with ROBOSEM, and to facilitate English learning. Their study showed meaningful results after four weeks of English classes conducted using ROBOSEM.

CHALLENGES OF RALL

As promising results of the educational effectiveness of RALL have appeared in numerous studies, many countries that teach English as a foreign language have begun to take the first step in RALL's research and commercialization. Korea is one such country where RALL is in full swing, with already over 1,500 robots employed in preschool play activities and attitude training, as well as over 30 English education robots currently in active use in elementary school afterschool programs. As RALL expands, there will be more emerging challenges for language educationalists to explore and address.

First of all, research on the system framework of RALL is necessary. The system framework of RALL consists of elements such as robot hardware, robot applications and visual contents. Each element needs to be designed in consideration of the language learning goals. Also, not only language educationalists but also educational service robot developers need to conduct collaborative research on designing guidelines for each element and on integrating these elements to carry out RALL successfully.

Secondly, more theoretical research on the current status of educational service robot technology, such as the RALL instruction model, is desirable. There needs to be consideration of how the teacher and robot would cooperate in the classroom and of what kind of teaching and learning model would be used in RALL. Both You et al. (2006) and Han and Kim (2009) have suggested several models, but a more specific teaching and learning model needs to be developed, reinforced with the language-learning experts' perspective regarding the most suitable type of robot (tele-operated, autonomous, and transformed type).

Third, more field experiments and studies on educational effectiveness are necessary to compare RALL to the conventional instruction methods of the multimedia program application model, native speaker collaboration model, and one-on-one videoconferencing model. Comparing educational effectiveness of such instruction models is very difficult to carry out, due to difficulties in conducting controlled experiments and its high cost. A Delphi survey with an expert group might be performed as an alternative.

Fourth, research on teacher education is essential since teachers are the ones who will be installing RALL. We need to find out what teachers need as prior knowledge (for example, basic knowledge of robot hardware and software), and develop a teacher education program. Also, consideration needs to be given to areas of possible concern for teachers when conducting RALL, such as whether a child is becoming too dependent upon the robot.

Fifth, research on various moral and technological issues arising through RALL applications are necessary. For example, RALL raises several problems, including: the exposure of the learning environment to outsiders through tele-conferencing; sharing data on class activities; students trusting a robot over the teacher; and the possibility of obsession with robots. Furthermore, solutions to class management problems, such as network breakdowns or robot hardware failure, are required.

Recently, with the emergence of an open robot software platform, robot applications enabling a variety of functions are being developed. Just as many people now have a personal computer, in the near future, personal robots (PR) may become the next paradigm-shifting tool for everyday life. Thus, as the computer sparked revolutionary changes in learning environments, studies needs to be conducted on how robots will bring about changes in education. Especially important will be the preparation of various approaches for RALL from the perspective of language learning and pedagogy, with a vision to evolve in tandem with already advanced developments in applications, programs, and services.

REFERENCES

Fels, D.I., & Weiss, P. (2001). Video-mediated communication in the classroom to support sick children: A case study. *International Journal of Industrial Ergonomics*, 28, 251–263.

Godwin-Jones, R. (2011). Mobile apps for language learning. *Language Learning & Technology*, *15*(2) 2–11. Retrieved from http://llt.msu.edu/issues/june2011/emerging.pdf

Han, J. (2010). Robot-aided learning and r-learning services. In D. Chugo (Ed.), *Human-Robot Interaction*. Retrieved from: http://sciyo.com/articles/show/title/robot-aided-learning-and-r-learning-services

Han, J., Jo, M., Park, S., & Kim, S. (2005). The Educational Use of Home Robots for Children. In *Proceedings of the 14th IEEE International Workshop on Robot and Human Interactive Communication (RO-MAN 2005)*, 378–383. Piscataway, NJ: IEEE.

Han, J., & Kim, D. (2009). r-Learning services for elementary school students with a teaching assistant robot. In *Proceedings of the 4th ACM/IEEE Human Robot Interaction*, 255–256. New York, NY: ACM

Hyun, E., Kim, S., Jang, S., & Park, S. (2008). Comparative study of effects of language education program using intelligence robot and multimedia on linguistic ability of young children. *Proceedings of the 14th IEEE International Workshop on Robot and Human Interactive Communication (RO-MAN 2008)*. Piscataway, NJ: IEEE.

Kanda, T., Hirano, T., Eaton, D., & Ishiguro, H. (2004). Interactive robots as social partners and peer tutors for children: A field trial. *Human-Computer Interaction*, *19*(1–2), 61–84.

Movellan, J.R., Eckhardt, M., Virnes, M., & Rodriguez A. (2009). Sociable robot improves toddler vocabulary skills. In *Proceedings of the 4th ACM/IEEE Human Robot Interaction*, 307–308. New York, NY: ACM.

Movellan, J.R., Tanaka,F., Fortenberry, B., & Aisaka, K. (2005). The RUBI/QRIO Project: Origins, principles, and first steps. In *Proceedings. The 4nd International Conference on Development and Learning*, 80–86. Retrieved from http://doi.ieeecomputersociety.org/10.1109/DEVLRN.2005.1490948

Park, S., Han, J., Kang, B., & Shin, K. (2011). Teaching assistant robot, ROBOSEM, in English class and practical issues for its diffusion. *Proceedings of IEEE A Workshop on Advanced Robotics and its Social Impacts*, http://www.arso2011.org/papers

Shuster, R. (2012, April 1). English teaching robot comes with a cost. *Korea IT Times*. Retrieved from http://www.koreaittimes.com/story/8216/english-teaching-robot-comes-cost

Sopher, J. (2011, February 2). Student uses telepresence robot to attend school. Retrieved from http://geekbeat.tv/student-uses-telepresence-robot-to-attend-school/

Yonhapnews. (2009, December 22). English tutoring Telepresence robot: Roti. Retrieved from http://www.youtube.com/watch?v=-_wa_SZaqQU

You, Z., Shen, C., Chang, C., Liu, B., & Chen G. (2006). A robot as a teaching assistant in an English class. In *Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies*, 87–91. New York, NY: IEEE.

RESOURCE LIST

Robots and RALL

IROBIQ. (2008). Yujin Robot. Retrieved from http://www.irobibiz.com/english/index.php

KEEPON. (2007). Beatbots. Retrieved from http://beatbots.net/

Microsoft. (2008). Robotics Developer Studio 4. Retrieved from http://msdn.microsoft.com/en-us/robotics/aa731517

NEC. (2012). Communication Robot PaPeRo. Retrieved from http://www.nec.co.jp/products/robot/en/index.html

ROBOSEM. (2010). Yujin robot. Retrieved from http://www.robosem.net/

VGo. (2011). VGo communications. Retrieved from http://www.vgocom.com/

Willow Garage. (2009). Retrieved from http://www.ros.org/wiki/