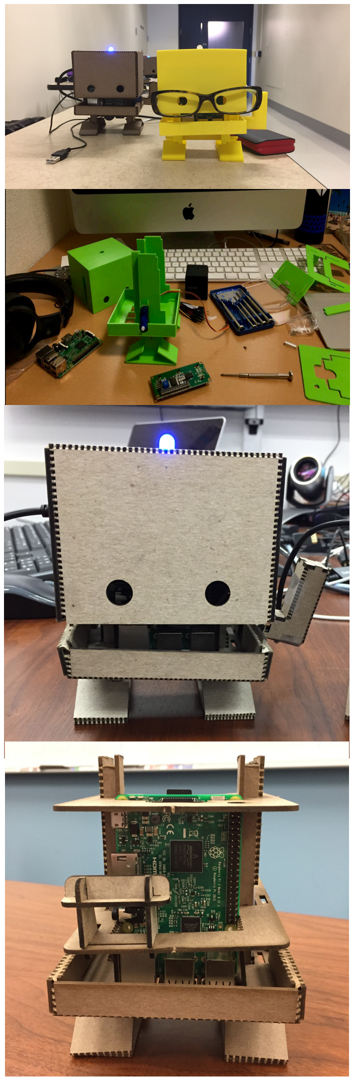

TJBot: An Open Source DIY Cardboard Robot for Programming Cognitive Systems

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CHI'17 Extended Abstracts, May 06-11, 2017, Denver, CO, USA
ACM 978-1-4503-4656-6/17/05.
http://dx.doi.org/10.1145/3027063.3052965

Abstract
TJBot is an open source, interactive robot designed to encourage people to build with cognitive services in a fun way. He is a paper robot, which can also be 3D printed, and comes with an initial set of recipes that bring him to life. Recipes are a combination of step-by-step instructions plus sample code that walk people through the assembly of the robot, its hardware components, and software code that connects him to Watson cognitive services. TJBot can be programmed to listen, speak, see and recognize, shine his LED, understand emotions, and wave his arm. TJBot was designed for two communities: makers, who enjoy the DIY aspects of building and programming novel devices, and students, who can learn about programming cognitive systems. At our demo, people can build their very own TJBot out of cardboard and interact with him through speech.

Author Keywords
Cognitive services; makers, open source; DIY; emotions; mood; robots; Internet of Things.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

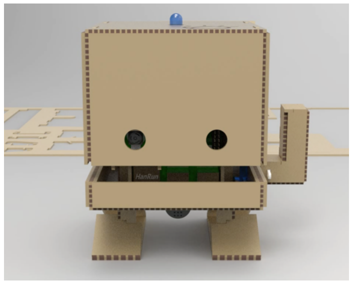

Figure 1: Front view of TJBot.

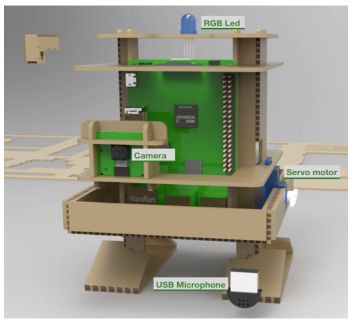

Figure 2: Front view (top removed) showing RGB LED, camera, servo motor and USB microphone.

Figure 3: Rear view (top removed) showing speaker and the empty space for additional sensors.

Introduction

Cognitive applications enable people to collaborate with AI technologies in order to discover information, analyze, make decisions, and solve problems.

Due to a number of recent breakthroughs in artificial intelligence, machine learning, computer vision, natural language processing, and conversational systems, our ability to create cognitive applications is becoming easier via the availability of cognitive services and APIs [1].

At IBM Research, we have been exploring applications of cognitive services with everyday objects, a.k.a cognitive objects [2]. Cognitive objects are capable of sensing the environment, performing computation, and providing feedback to a person. As part of our exploration, we have developed a new kind of object – a paper robot that embodies a number of cognitive services, including visual recognition, conversation, sentiment analysis, speech to text, and text to speech. We designed TJBot as an open source platform to enable people to learn and make interesting things with the IBM Watson cognitive services.

In a sense, TJBot represents a restriction of a broad design space of cognitive objects by providing a limited set of concrete functionalities. The robot can shine its LED, wave its arm, speak (or play sounds) via its speaker, listen via its microphone, and see via its camera. Our goals with TJBot are to understand a) what kinds of new behaviors people create, b) what the best practices are when designing interactions with the robot, c) what kinds of capabilities people assume the robot has, and d) whether restricting the design space motivates people to learn about cognitive services and build new things with them.

We designed TJBot for two kinds of communities. The first is the maker community, who enjoys the DIY aspects of creating and building. TJBot is ultimately a blend of hardware and software, requiring hands-on laser-cutting and assembly of the cardboard (or 3D printed parts), integration of the electronic components (LED, speaker, servo, and Raspberry Pi), and execution of software code. Our second target community is students, and we have started a school program with 11 high schools and middle schools across the United States. Seven of these schools are Pathway to Technology schools[1], designed to provide their students with a high degree of technological exposure. It is our hope that the cute design of the robot, plus the ease of use in which he may be programmed, is a significant motivator for learning about programming and using cognitive services.

TJBot is open source, including both the robot housing and software libraries. His design files and software can be found on GitHub[2] and his recipes can be found on Instructables[3].

Design of the Cardboard

Since paper-based sketching encourages people to explore more ideas without being buried in inappropriate details and stimulates creativity, we designed TJBot with simple materials and forms to

1https://en.wikipedia.org/wiki/Pathways_in_Technology_Early_College_High_School

2 http://ibmtjbot.github.io

3 https://www.instructables.com/howto/tjbot/

Figure 4: TJBot DIY Kit contains electronics and a laser cut cardboard with parts that can be folded or snapped.

Figure 5: A group of volunteer researchers assembling the TJBot kits.

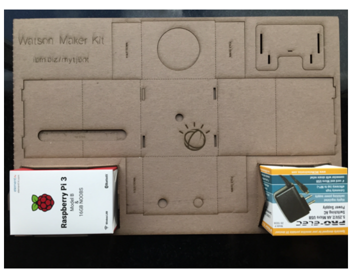

Figure 6: TJBot Cardboard

encourage people with limited programming background to experience 'embodied cognition' and start embedding AI technologies into objects. Guiding design principles in creating TJBot were:

- *Robot to capture imagination of all ages*
- *Human features to fit cognitive aspect*
- *Cute proportions for an approachable/likable personality*
- *Simple forms to reflect basic materials and construction*

TJBot presented a unique design challenge as it blends the low tech qualities of cardboard with the high tech requirements of electronics and software. Through numerous design iterations and prototypes, we worked directly with hardware designers and software developers, to refine the design of TJBot to a cute looking robot with Raspberry Pi inside. People can produce the physical body of TJBot by either laser-cutting cardboard (each part can be folded or connected without the need for any adhesives or fasteners) or 3D printing from common plastic materials.

TJBot Hardware

TJBot has a Raspberry Pi 3 inside. It is a small Linux computer that we can use to connect to Watson API and control TJBot's hardware. The robot frame has placeholders for a Raspberry Pi camera behind the left eye, a speaker and a microphone inside the bot to enable a conversation, a servo motor to move the right arm, a RGB LED to shine and reflect emotions. Inside the head is left out empty to accommodate additional sensors. For example, some of the makers used TJBot as a personal weather station. Figure 2 and 3 show some of the TJBot components.

Software Library

In order to make TJBot easy to program, we have created a software library (e.g. an API) that encapsulates the robot's unique capabilities and connection to cognitive services. The library is written for Node.js, an open-source, cross-platform runtime environment for developing applications in JavaScript. To get people up-and-running with TJBot without having to write code, as well as teach people how to program TJBot themselves, we created a set of sample instructions (called recipes) that demonstrate different capabilities. For example, one recipe makes TJBot introduce himself using Text to Speech (the robot simply speaks, "Hi, I'm TJBot"). Another recipe allows a person to have a simple conversation with TJBot, asking questions such as "What is your name" or "Tell me a joke." TJBot can also monitor Twitter for tweets, and a third recipe monitors for tweets containing a specified keyword, performs a sentiment analysis on those tweets to determine a dominant emotion (e.g. joy, anger, sadness, etc.), and then changes the color of his LED based on that emotion.

Pilot User Study

To evaluate early reactions to TJBot, we introduced TJBot to a group of 37 developers at a developer conference[4]. Participants were asked to evaluate TJBot using a Likert-type scale (1-7)[5] on the following parameters.

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[4] http://www.ibm.com/watson/developer-conference/

[5] A rating of 4 and above was considered high.

Figure 7: Kids in South Africa building their own TJBot (ref: https://twitter.com/LayoRay).

1. *Visual appeal:* 91% respondents felt the bot was visually appealing (t = 4.2).
2. *Functionality:* Perception of functionality: 83% felt the robot had a good set of functions. (t = 13.96)
3. *Interests in Cognitive Application design:* 84% indicated strong interests in building cognitive applications using TJBot (t = 7.6)

65% of the participants had less than a year experience programming with Raspberry Pi while 67% had more than 3 years of general programming experience.

Participants appeared to be particularly engaged by the visual appearance of TJBot and described him as "cute"," adorable"," cool"," pet". Most of them expressed a strong desire to take a TJBot home even before learning about his capabilities.

They expressed TJBot as an easy way to understand how different cognitive services work together (e.g. speech to text, text to speech, vision recognition).

Conclusion

Since its release on November 9, 2016, TJBot has received global attention. People in Italy and Brazil got TJBot to speak Italian and Portuguese. We received pictures of elementary school kids in South Africa building and painting their TJBot (Figure 7). TJBot has been programmed as a security device, a personal weather station, to recognize sesame street characters, to control drones, or just being a charming caring companion. In the CHI demo session, we will walk the audience through how to get started, build their very own TJBot, and use one of his initial recipes to bring him to life. They will also be able to interact with TJBot and test out some of his capabilities. In this demo session, they can interact with Watson Conversation, Visual Recognition, and Tone Analyzer. TJBot is connected to Twitter monitoring the conversations around CHI. He uses Watson Tone Analyzer to understand emotions and shines different colors based on that. For example, he shines yellow when people are happy. The audience can interact with TJBot through Twitter but also ask questions and provide voice commands to control him. Some examples are: "What do you see", "introduce yourself", "play some music", or "Dance".

We have been working with 3rd parties to make it easier for people to obtain a kit. Our next step would be a) to take TJBot massively available, b) work together with the maker community to expand on the capabilities of TJBot and simplify his software libraries, and c) continue working with teachers to explore the potential of TJBot for education.

Acknowledgements

We thank the maker community, teachers, and coordinators of PTECH program, and all the volunteers who contributed to this project.

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