Ani-Bot: A Mixed-Reality Ready Modular Robotics System

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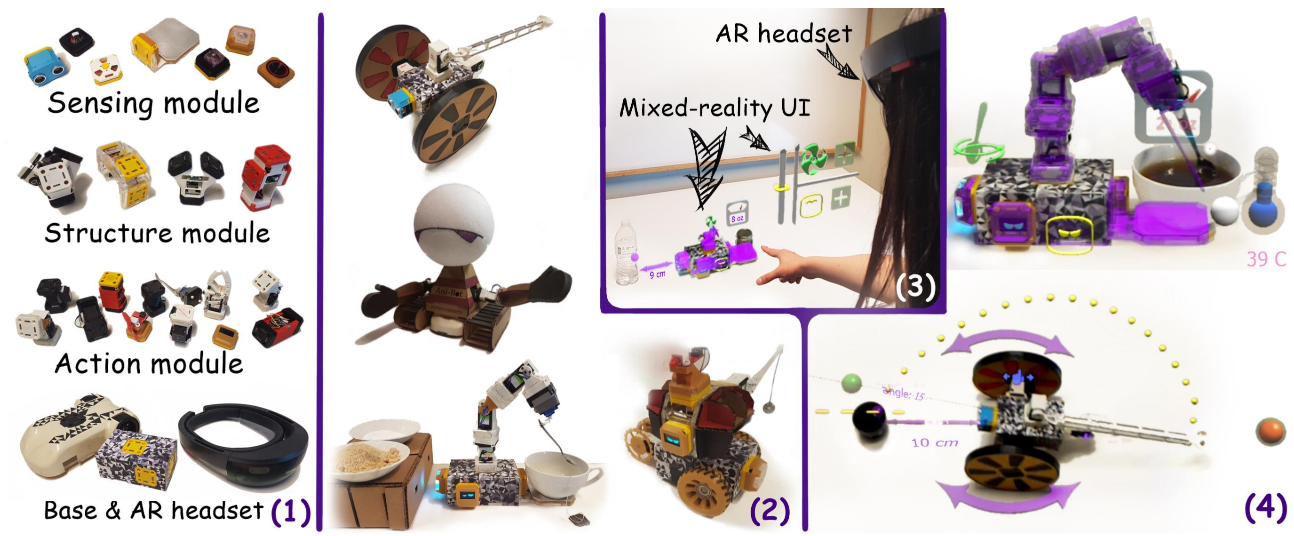

Figure 1. Ani-Bot system overview: Ani-Bot provides users with (1) a modular tool kit that allows them to (2) assemble and construct robots with crafted DIY objects, and (3) use mixed-reality interaction to perform direct manipulation, sensor driven programming, and animation authoring. (4) Users can easily program their robots to perform environmental interactive tasks, like adding sugar into a teacup or shooting bullets into a bowl.

ABSTRACT
We present Ani-Bot, a modular robotics system that allows users to construct Do-It-Yourself (DIY) robots and use mixed-reality approach to interact with them. Ani-Bot enables novel user experience by embedding Mixed-Reality Interaction (MRI) in the three phases of interacting with a modular construction kit, namely, Creation, Tweaking, and Usage. In this paper, we first present the system design that allows users to instantly perform MRI once they finish assembling the robot. Further, we discuss the augmentations offered by MRI in the three phases in specific.

Author Keywords
DIY robot kit; Mixed-reality interaction; User interface.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation: User Interface

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INTRODUCTION
DIY modular robotics has always had a strong appeal to makers and designers; being able to quickly design, build, and animate their own robots opens the possibility of bringing imaginations to life. Existing robotics kit primarily uses Graphical User Interface (GUI) or Tangible User Interface (TUI) to control and program the DIY robot. However, both approaches have their limitations: the GUI approach lacks connection and consistency between the user behind the control interface and its physical target [1]; While the TUI approach generally suffers from limited control capability due to the lack of versatility and maleability [3].

Our proposed Ani-Bot system utilizes MRI to bridge the gap by superimposing the control interface onto its physical target while allowing for comprehensive control and programming. The system's assembly awareness capability allows constantly updating of the virtual model based on robot's physical configuration. As is shown in Figure 1, the virtual model is overlapped with the physical robot in the view of AR headset which is ready for MRI. We introduce a set of features which are tightly coupled with three lifecycle phases of a construction kit: Creation, Tweaking, and Usage [2]. First, Ani-Bot provides interactive manual and suggestive guidance to help users create their robots. Then, using the virtual tryout feature in the system, the constructive assembly can be further tweaked and improved to meet functional requirement.

Finally, the mixed-reality UI enables users to effectively interact their robots with the surrounding environment.

ANI-BOT OVERVIEW

System Workflow

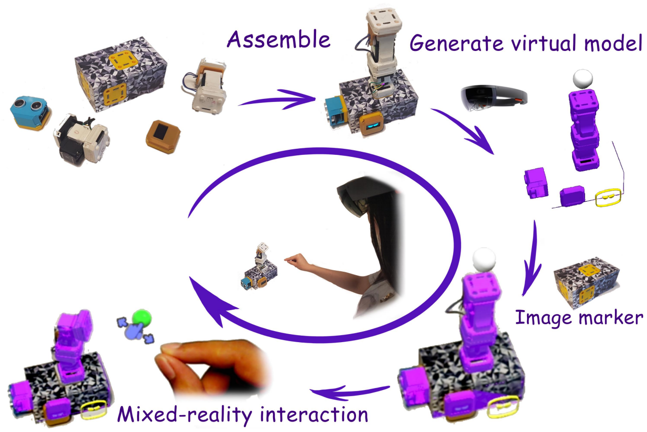

Figure 2. Ani-Bot system workflow

Ani-Bot embeds MRI with DIY modular robotics and the workflow is illustrated in Figure 2. All modules in Ani-bot system has processing power, and can be connected to each other to establish network communication. The physical robot is therefore aware of its own assembly configuration and sends the data to the AR headset (Microsoft HoloLens) to generate the corresponding virtual model. By detecting and tracking an image marker on the Base module, the virtual model can be superimposed onto its physical target for the mixed-reality interaction. The kinematics data of the virtual model are constantly transmitted to drive the physical robot. In this way, users interact with physical robot by manipulating the virtual representation in the MRI.

DIY Modular Robotics with MRI

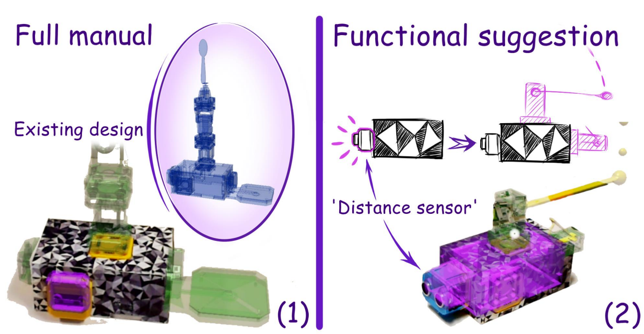

Figure 3. Creation in MRI: assembly guidance and functional suggestion

Creation. Utilizing MRI, Ani-Bot provides user with virtual assembly guidance for existing design (Figure 3 (1)). The virtual guidance is interactive and gives real-time color-change assembling feedback. Besides full manual, the system can also provide structure suggestion according to the input module. For example, in Figure 3 (1), a thrower setup with default trajectory is suggested initiated by ‘Distance Module’.

Figure 4. Tweaking in MRI: virtual tryout for functional improvement

Tweaking. Instead of physical tweaking, which requires effort for iterations with real robots, Ani-Bot provides users with virtual tryout to improve an ineffective design into a working configuration. As demonstrated in Figure 4, upon removing the end-effector, users can activate tweaking mode with voice command. They can try different configurations and compare their performance in the mixed-reality simulation, and then choose proper structure design for assembly.

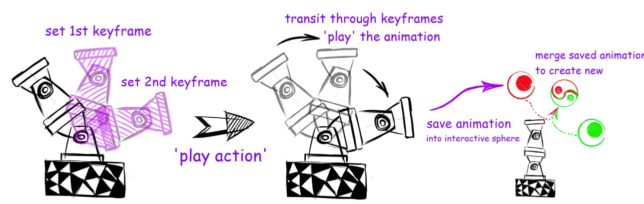

Figure 5. Mixed-reality animation authoring

Usage. Utilizing the property of MRI, Ani-Bot allows users to easily define and program environmentally interactive tasks for the robots. Ani-Bot’s sensing modules expressively visualize the sensing data (temperature, distance, etc.) from the surrounding environment (Figure 1 (4)). With the sensor programming UI (Figure 1 (3)), user can easily define sensor driven events. For example, turn on the ‘fan’ when the weight exceeds the set value, otherwise display a ‘smiling face’. Moreover, Ani-Bot enables users to define and manage keyframe animation by manipulating the virtual model and setting the keyframe positions, as illustrated in Figure 5. Upon playing via voice command, the robot performs the animated movements and thus accomplish the defined tasks.

CONCLUSION

We propose a mixed-reality modular robotics kit that allows users to construct DIY robotics and utilize mixed-reality interactions to control and program. We present the design of the system workflow embedding MRI with DIY modular robotics. By designating Ani-Bot’s MRI features in the three major phases (Creation, Tweaking, Usage) of modular construction kits, the system has strong potential to deliver a novel user experience in DIY modular robotics.

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