IOTOM, Guided Assembly for Human-Machine Dialog

Penny Webb
MIT Media Lab
Cambridge, USA
pewebb@mit.edu

HyeJi Yang
Harvard University
Cambridge, USA
e-mail address

Thomas Sanchez
MIT Media Lab
Cambridge, USA
thomassl@mit.edu

Meryl Fang
Wellesley College
Cambridge, USA
mfang@wellesley.edu

Manisha Mohan
MIT Media Lab
Cambridge, USA
e-mail address

ABSTRACT

As we approach an ever more autonomous environment where machines and robots transform themselves for our desired needs [7], the question of human influence manifests. What will our role be in a future where materials hold agency through contextual decision-making? This paper proposes a platform for human-machine conversation within the physical environment, whereby algorithmically defined choices are coupled with human interaction for a computationally guided approach to construction and tangible decision-making. The interface of human-machine interaction is constrained by the functionality of both living and non-living entities, creating a framework for a dual agent (machine-human) process of 3D shape making.

Author Keywords

Human-machine conversation; autonomous robotics; connected blocks; machine learning; cybernetics;

INTRODUCTION

Until two decades ago, computational functionality was achieved though explicitly programmed human input to compute linear algorithmic tasks. However, with more recent growing efforts in machine learning and AI, we see an alternative future whereby machines may no longer be subservient tools, but computationally profound, learning entities. As such, the foundational framework of digital products is seeing a paradigm shift from passive to active agents. This raises the question; what new values or narratives will unreliability and contingency bring to interfaces? Through our platform we question this shift, within the field of HCI, by introducing Gordon Pask's Conversation theory [2] as a model for learning by observing, as well as informing by doing. By this we intend to provoke a school of thought within HCI that breaks away from a traditional master-slave relationship within interface design.

What we present here is a dynamic building system, utilizing electromagnetic connectors to provide non-linear feedback through contingent I/O. The system redefines autonomous output within non-human, computational agents, by, rather than self assembling, guiding the human-user within their structure making. This is achieved by providing points of magnetic attachment or repulsion between blocks, through computationally generated forms. This can be achieved by uploading pre-designed digitally rendered models to the block elements, triggering specific magnetic configurations within the physical forms. The aim of this prototype is to generate a non-verbal dialog between the user and the computer, whereby human input (in this case the act of building), is negotiated with the non-human agent through binary feedback, which the user can choose to comply with or decline.

Another analogy we use to explain our system is the re-configurability of atomic structures. In this sense, each element functions as an individual atom, and through human intervention, i.e. the building process, a diverse set of 3D configurations can be formed.

Beyond the conceptual approach to this design, we have identified real-world applications whereby the use of such a system would be applicable for every-day, or specific use cases.

RELATED WORK

Our work intersects between programmable matter, modular robotics and human guided assembly. We review the current investigations within these areas. There have been a number of inquiries in the development of intelligent blocks which promote creativity and learning through assembling physical objects; Triangles [3] and Topobo [4]. Researches in the field of robotics have explored how independent modules can assemble themselves by inner-propulsion, leading to a system for self-assembly robots [5]. Other researches have explored the area of programmable matter though the composition of small, connected and intelligent models. In Robot Pebbles, small-modulated robots are latched together though the magnetic connection of neighboring blocks [6]. Or towards the goal of forming shapes through self-disassembly, modules are initially assembled then self-disassembled in an organized form to build the final shape [7]. In contrast to the preceding work, our research focus on incorporating interaction within modular robotics by giving a bi-directional choice in how to assemble the modules. Through our work it is possible to interact with the drop/latch mechanism of the modules. Giving two types of interaction: human guided assembly and self-disassembly.

IMPLEMENTATION

We have prototyped variants of the physical components: two truncated cones and one cylinder. Each truncated cones is embedded with two electromagnets on the faces, and the cylinders are embedded with two non-magnetic metallic disks on the opposite faces, as shown in figure 1. Each cone contains an Arduino Pro Mini, 9V battery and electronic circuit to enable and disable each electromagnet at our will. The electromagnets are used for two reasons: we can control the connection between modules and provide users with haptic feedback of repulsion or attraction when connecting blocks.

Two modules are linked together by the electromagnetic latching mechanism turning on/off. This mechanism enables the user to use the force of attraction or repulsion to know which orientation is correct, thus eliminating erroneous connections. Due to their natural tendency to self-align the system is capable of aligning with its connected neighbor no-matter transition process. Our implementation focuses on the human-guided process, but other self-organized processes may be used: self-assembly by random actions [8] and by robot-aided assembly.

Figure 1. Haptic feedback of the first prototype IOTOM blocks

APPLICATIONS

Electromagnets have been explored since 1820, after being discovered by Hans Christian Oersted. The application ranges from levitation to day-to-day activities. By using IOTOM we aim to give the ability to create and discover new possibilities to the common user.

We are surrounded by pre-configured objects with fixed orientations. IOTOM blocks define every component as an individual 'atom' that can combine with another IOTOM to form a newly configured object with varied applications. Figure 1. Depicts how four IOTOM blocks combine to form a range of objects as per need. The variable magnetic strength gives the user ability to change the polarity of the IOTOMs. The application can be dominantly explored in domestic setups, especially within city homes. [10]

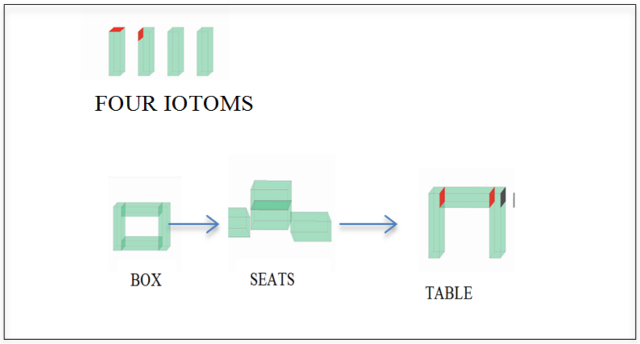

Figure2. Rearrangement of IOTOMS to form different application based objects.

IOTOM blocks can be explored as memory cells for constructing pre-programmed models. One use-case example for this would be; with online marketing taking a toll over the shopping experience, the shopper could get their articles delivered in boxes. For large items, generally the components are sent after disassembling. The user reads the manual for assembling the goods. Sometimes the user is able to assemble it, but sometimes the experience is tedious and overly complex. Figure2. shows a person struggling with the assembly of a flat-pack lamp. Self-programmed memory of IOTOM blocks could be used for assembling the goods more swiftly as the feedback mechanism allows the user to understand whenever she/he is placing or positioning it incorrectly, helping to solve puzzles of daily life with an element of ease.

Figure2. Person struggling while assembling his dismantled goods.

A wide variety of systems are composed of many sub-systems. For example a complex system like a car engine, V12 Ferrari 512 Turbo RUN comprises of 1800 parts. If it is disassembled, reassembly for the common user can be next to impossible. The systems, if programmed using IOTOM blocks, will simplify tasks such as this though instantaneous feedback.

The feedback mechanism is sensory. It is unlike existing feedback or alarming systems used. It is not of the form of vibration, sound etc., instead it is a form of repulsion which informs you that the connections which you are trying to make are just not meant to be. The objects will not be able to cling to one another however hard one may try. The basic laws of magnetism will not allow you to succeed.

Communities which work with electronic gadgets have a fair amount of experience with electronic components burning off every now and then. Many times it is just because of a wrong connection due. Follies of this kind can be rectified if we begin to use IOTOM blocks as connectors while designing our electronic components and circuits.

FUTURE WORK

Future development will focus both on exploring the technical properties of the current blocks, and on defining more concrete applications for the enhancement of human-machine bidirectional interaction.

Future iterations aim to take in environmental parameters (achievable through a network of sensor nodes), generating output based on sensed as well as programmed data.

The current construction of IOTOM, built with rigid material, uses magnetism as connectors. The material and connecting points may be constrained for the implementation of a human-machine conversation. The next steps would be using soft material to allow more versatility. For example, the faces of a silicon cube could be stretched out based on the algorithmic pre-configuration. The composite of soft and hard material would also create a gradient of functionalities that is tailored to different needs. This would go beyond rigid artificial three-dimensional geometry, to allow a more organic shape range.

We also plan to explore alternative ways of connecting the blocks. For the time being, due to the nature of magnetism, we only receive binary information based on the on/off of the electromagnets. To build blocks resembling living entities, we can embed different types of sensors in the blocks for various functionalities.

Meanwhile, our vision of creating human-machine dialogues may require more justifications upon its applications and mappings in the physical world. The middle ground of self-assembly robotics and human-guided assembly initiates a continuous cycle of human and non-human agents' input and output. The concept leaps from the traditional human-machine hierarchy: yet our proposed applications seem to be more confined in the hierarchical realm of interactions. Subsequently, we plan to produce the blocks in bulk to test out a more intuitive mapping between the prototype and the vision.

CONCLUSION

This paper suggests a framework for interacting with programmable objects that could further create bi-directional interaction with users. The goal is to break away from the traditional hierarchical relationship between human users and objects. The programmable objects with its own will and intention both limit and aid the users' needs.

As a proof of concept, we developed simple prototype blocks, "IOTOM", with electromagnets embedded on the faces. The prototype was used to demonstrate 1) computer-guided assembly 2) telepresence assembly and 3) construction-feedback mechanism. Through programmable configurations, the connections and disconnections of blocks conveyed certain information, creating various dialog modalities with human users. There are challenges in understanding why the control needs to be shared with the machines, however, we believe that introducing the unreliability and the contingency in human-machine interactions will create new meaningful physical culture in the near future.

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