Envisioning the Robot Design Studio

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The design studio encourages communication, creativity, and ideation. Often the domain of architects, industrial, and graphic designers, the studio environment has been shown to be effective in other domains, from software design to public relations firms. Robotics, with its necessarily interdisciplinary nature, is an ideal field for permeation by design studio culture.

The Design Studio

Anyone who has visited an architect's office has experienced a design studio. They are characterized by open, collaborative workspaces and ideally, a high level of creative energy. Most design studios contain an abundance of supporting and in-process design material – drawings pinned to walls, physical models, and clippings from periodicals which have triggered one idea or another. Many designers choose to work in the studio environment because it encourages spontaneous, frequent communication between designers.

It is worth addressing the distinction between design studios in education and industry. A designer's office exists to optimize creativity and workflow, and perhaps profit as well. Undergraduate architecture education co-opts several of the professional studio's features, but ends up with a more competitive, isolated version. The aim is to provide students with the skills necessary to thrive as designers, but the "studio culture" that is created is often less productive and focused than we might find in a professional studio.

Certain research labs bear a resemblance to design studios but are often less focused on materiality. The design studio, with its finished and in-process artifacts, encourages cross-pollination between designers and between projects. Often, in informal sessions, designers will "pin up" their work for others to review and collaborate [4].

A key difference between the design studio and the research lab is the presence of formal critiquing sessions, or *crits*. Crits encourage thoughtful preparation and presentation, and often serve to kindle new design ideas or directions. In a typical design studio, the crit can help designers evaluate each other's work in a more holistic fashion than through the day to day communication about design details. Wolf writes that, "designers benefit because the crit provides insight that can make them better designers." [7]

The Robot Design Team

The design of new robotic systems is often carried out by a team of people over a fairly long period of time. Coordination of and communication between design participants can

factor heavily in the success of the final project, producing a tightly integrated robot or a disjointed, buggy one.

There are three core fields involved in robotic development. Mechanical engineers create the hardware systems and structures necessary for actuation, locomotion and stability. Electrical engineers create circuits which tie together sensing, power and communication. Programmers create the robot's behaviors, knowledge and personality.

Experts in the robot target domain are often included in the design process. It would be impossible to design medical robots without the participation of doctors. Robots for education require teachers, and those for the military require military input.

It's important to note that these design participants are necessary to make a robot *work*, which is the goal that most researchers and robotics companies are heading toward. As the problems of basic functionality begin to be solved, it becomes increasingly important to make robots *work well*. Psychologists are needed to analyze the interaction between robots and humans. Industrial designers are needed to embody and optimize those interactions into a product. Ethnographers and sociologists are needed to evaluate the systems in the context of social situations. This is only a partial list.

The Robot Design Studio

With the number and variety of participants in a typical robotic design project, communication and close collaboration become paramount. The design studio, with spontaneous communication and structured critiquing sessions, is an ideal environment for robotics development. The design studio encourages cross-pollination between designers working in different disciplines and on different projects.

For a strict engineering design project, we might imagine a complex system that could be built by separate teams that have agreed on tightly specified interfaces to connect their work. A commercial airliner or a fully specified software application could be constructed in this manner. *Robotics projects, however, are rarely precisely defined from their inception.* The volatile technology, materials and algorithms that comprise current-day robots necessitate a flexible and adaptive design process. Rarely is a robotics problem fully specified.

While it may seem odd to make a distinction between the design of an airliner and of a robot, the rate of change of robotics technology differentiates these design processes. The airliner certainly contains evolving technology, but these changes are incremental, the fundamental principles of flight and control remain constant. At the current state of robotics, frequent changes in sensor and power technology redefine the capabilities of a system. New algorithms make certain tasks possible that were impossible yesterday. Each of these advances necessitates change through the whole of design. A new sensor technology, for instance, will require new programming to operate and new mechanical design for mounting and routing. In robotics design, close collaboration between members of the design team can determine the success or failure of a project.

Certain aspects of design studio culture have been characterized as counterproductive and unhealthy [3]. The bulk of this criticism is leveraged at architecture schools and the cultural pressure to put in multiple all-nighters, sacrifice a healthy lifestyle, and confuse effort with results. While issues like these may be endemic to undergraduate architecture education, they are due to a specific self-imposed culture, not results of the design studio environment.

Some Examples

Our studio, the Computational Design Lab at Carnegie Mellon University, attempts to carry the benefits of the design studio into the domain of robotics. Although we are located in the School of Architecture, several of our members have a background in computer science. We are exploring a broad agenda, including the development of several robotic construction kits [1] [5].

At Wellesley College, Turbak and Berg have taught *Robotic Design Studio* for several years [6]. With students from a variety of disciplines, they attempt to teach certain fundamental engineering concepts (feedback, managing complexity, constraints, etc.) in the context of a design studio. While they don't utilize formal crits, they note that the studio environment they create encourages both significant interdisciplinary and inter-project communication.

Several exciting robots have been developed by Flower Robotics Inc., the Japanese studio run by Tatsuya Matsui. Posy, the "flower girl" robot was featured in the movie *Lost in Translation*, and Palette, a robotic mannequin, has been displayed at the Louis Vuitton store in Paris [2]. Posy and Pino, another humanoid robot, are prominent in robotics literature and extremely successful. Matsui's background is in architecture, however, and Flower Robotics' designers, architects and engineers function as a design studio. It seems apparent that the design process is what separates Posy from the multitude of less evolved robots.

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