1. Overview

The book will teach its readers how to create robotic art by exploring concepts in art and computer science, with a focus on the intersection of these two fields. We define robotic art as projects that involve a control system, use sensors to receive input, and produce output using motors, sound and other means. As we define them, robotic art projects are tangible and often kinetic; our book will not address art that is created primarily for a computer screen.

The book will introduce Artbotics, an educational program that is a collaboration between artists and computer scientists which uses robotics technologies and fine arts pedagogy to teach computer science to undergraduates and high school students. These project-based courses have culminated in public art exhibitions and other projects. The emphasis on designing interactive works for public consumption encourages students to think about human-user interaction with the physical world and their object’s interaction with people for whom the methods of interacting with the project will not be a foregone conclusion. Robotic art that is meant to be handled by the public puts the Computer Science issues of user interaction and usability at the forefront.

Artbotics offers a creative way to attract students of diverse backgrounds and expertise to a Computer Science education. It also introduces computing to the general public through art shows at local galleries and museums. Because the projects are presented as a creative practice and use technical problem solving as a mode of personal expression, arts and humanities students feel less intimidated by the “hard science.” Science students, in turn, can explore aesthetic concerns and experiment first-hand with the design and user problems unique to a public art context.

More information about Artbotics can be found at the program website: http://artbotics.org. This site includes a history of the program, images, lab manuals and pedagogical slide shows for both the high school and college audience. As this site is maintained by our project staff at UMass Lowell, we envision it hosting ancillary materials such as language specific lab manuals for programming Arduino, Super Cricket, and the other technologies that may come along in the future. While teaching programming logic is a core component of Artbotics, for this book we will teach programming logic without focusing on a particular language in order to keep the information as broad based and current as possible. The job of navigating specific languages for current micro-controller platforms will be delegated to a pedagogical area of the website which will be maintained independently.

2. Setting

The core of the book’s content describes an interdisciplin ary collaboration between art and science: a valuable relationship that is sometimes lacking in schools, especially as the skills
covered in an art education are often denigrated in favor of hard science education. Some universities offer a “Computer Science 0” class, using basic level programming concepts to attract and introduce more students to computer science. Some art schools (e.g., Stanford University, The Art Institute of Chicago, and New York University) are heavily involved with new media art and are looking for ways to better integrate technology into their classes. The materials in this book are valuable tools that can bridge art and computer science departments and offer solutions to problems of attracting students and finding the right curriculum to combine art and technology.

In the last ten years, new electronics systems have become cheaper and more accessible to the non-scientist user and hobbyist. Since 2000, micro-controllers such as the Arduino, Cricket, Lego Mindstorms and Basic Stamp have become more powerful and readily available. They offer plug-in sensing peripherals that detect motion, temperature and light; kinetic elements like motors, levers, and cams; and expressive elements including audio, lights, and LED displays.

Artists will be attracted to the jargon-free overview of robotics and computer science, and the blend of fine art project examples and artist interviews. DIY designers and inventors will enjoy the hands-on projects described and will learn how to scale up their explorations as their interests demand. Computer Scientists will enjoy exploring aesthetic applications of their area of expertise and benefit from the discussions of design, usability, and human-robot interaction.

3. Robotic Art

While automata in art in the 18th century is often cited as the pre-history of robotic art, this book will look closely instead at the last forty years of interactive and kinetic art, starting with projects by Nam June Paik, Experiments in Art and Technology (E.A.T.) and Billy Klüver. This period is often considered the watershed of engineering and art working together in America and includes examples of modern robotics and fine arts. As our Artbotics projects are tangible works that involve a control system, information input and output, we will define our projects as “Robotic Art”, an area of creative exploration that fits into the “New Media Art” genre, alongside interactive, kinetic and electronic art.

We will contextualize our projects with practicing and recent artists works. We will include interviews with contemporary artists, focusing on diverse national and gender backgrounds, as well as diverse expressive practices. These interviews will be inserted as sidebars throughout the book, locating each appropriately to the current topic under discussion. Candidates for interview include Rafael Lozano-Hemmer, Jen Hall, Arthur Ganson, Camille Utterback, Ken Rinaldo, Christian Moeller, Choe U Ram, Zune Lee, Wang Ji Won, Louis-Philippe Demers and Daniel Rozin. We will also interview roboticists; candidates for interview include Joe Jones,
4. Content

The book is divided into four parts: the first focuses on the theoretical, high-level concepts embedded in Artbotics (e.g., art, robotics, interactivity), and the last three give the reader more specific tools to begin building an Artbotics project (e.g., design tools, programming, electronics, final project installation). Each part will contain several chapters on the part’s topic. Here we provide an overview of the parts. A more detailed outline can be found below in section 8.

In Part I, we will define and discuss interactivity, how to design for it, and how to translate some of those ideas into programming logic. We will introduce technology in contemporary art as already noted. We will discuss robot morphologies, modes of interaction with robots, and human expectations of interaction. We will introduce several robots that “make art” including Artaic and Gigapan and “robots as art” made during the Artbotics student program.

In Part II we will examine the use of visual 2-D design language to communicate concepts, narrative, subject matter. We will explain in common terms the functions of technologies such as LED’s and sensors, introduce basic electronics information, and discuss programming for sensor input and behavior repetition.

Part III will focus on 3-D design with motors and demonstrate mechanisms. We will offer an analysis of the language of art that includes motion, time, and interactivity elements, and we will discuss the language of materials. We will discuss different types of motors that can be used and how circular motion can be converted to other types of movement with cams, gears, and levers. Programming concepts will include decision making processes and the use and definition of variables and functions.

Part IV will discuss the project process including brainstorming, prototyping, exhibition design, and installation procedures. We will discuss documentation of projects and user manuals.

Each chapter in the book will provide references for further reading. We will provide a full bibliography in the Appendix, along with resources for getting the parts needed to create Artbotics projects. Some chapters will also reference online materials, such as technology-specific lab manuals, which will be hosted on http://www.artbotics.org before publication of the book.

This book will be written by Dr. Holly Yanco (Professor of Computer Science, founder of the UMass Lowell Robotics Lab and developer of the Artbotics program), Ellen Wetmore (New Media Artist and Assistant Professor of Visual Art), Hyun Ju Kim (Assistant Professor of Visual Art and developer of the Artbotics program), and Adam Norton (developer of the Artbotics program, graphic designer and educator).
5. Market

There is no comprehensive guide to interactive/kinetic art with a how-to component for classroom or self-teaching. Our book is grounded in the latest methods of computer science and contemporary art. It offers a foundation discussion and lessons in both fields with sample hybrid exercises.

We offer a book designed to be used as a text for university and high school teaching, artists, roboticists, DIY enthusiasts, and the broader public. For hobbyists and technologists, integrating technology and art projects has becoming increasingly popular due to entities such as Make Magazine and the Instructables web site. The Artbotics materials lend themselves directly to this market, with chapters of our book covering different kinds of technology that are already commonly used within this demographic. This notion of combining art and technology stems from the practice of new media art, where artists combine computer science and technology into their artwork. Making work that is interactive and requires active participation from the viewer is still a very exciting and interesting realm for artists. Our book introduces concepts of programming, interactivity, and technology in a very accessible way for artists.

The book’s content is derived from our curricula for the Artbotics college course and after-school high school program. Technologists looking for an art and design perspective on their work will find useful our discussions of each, as will artists looking to produce kinetic sculpture or add interactivity to their work. We will engage readers with technology descriptions, instructions and coding written in plain language; background information and examples on current art practices; trends in human-robot interaction; and art instruction emphasizing play and discovery.

There is no title on the market similar to the one we are proposing. Discussions and examples appear frequently in popular media (e.g., Wired, NYTimes, Bloomberg.com, etc.). In academic art books, there are a few catch-all titles for New Media that might include a chapter on robotic art (e.g., the books by Michael Rush, Christine Paul, and Edward Shanken). There are also monographs on artists such as Alan Rath and Rafael Lozano-Hemmer. However, our book documents a hybrid art-technology teaching practice: its discoveries and successes, and provides a model for those wishing to start their own educational practice.

Attracting students to Computer Science has always been a challenge for educators. Artbotics dispels the notion of the asocial programmer and gives students the chance to build and program a piece of kinetic sculpture, taking the abstract concepts of programming and making them physically tangible with robotics. Likewise, artists wishing to branch into interactive work often find the barriers to participation high as computer programming, kinetics, and electronic engineering can be difficult to master.
6. Biographies and Program Background

The Artbotics program started in 2006 as a collaboration between the University of Massachusetts Lowell and the Revolving Museum, both located in Lowell, Massachusetts. The program began with a summer pilot involving 8 students combining art and technology for two group projects. This pilot led to subsequent after school high school programs and college courses at the Revolving Museum and UMass Lowell, respectively. The Artbotics classes have been used to increase participation in computing among women and minorities through the use of interactive technologies, broaden student understanding in the field of computing and new media art, and to introduce interactive sculpture to the public through art exhibitions of student projects. Educator workshops, middle school summer camps, and other iterations of the program have helped spread the Artbotics curriculum and materials to cities beyond our Lowell home base. Schools throughout Massachusetts have adapted our curriculum, as well as those in cities outside of New England, including San Jose, CA and Chicago, IL. Artbotics is continuing to grow in popularity among educators as a creative and innovative way to generate interest in STEM (science, technology, engineering, and math) fields and new media art.

Dr. Holly Yanco is a Professor in the Computer Science Department at the University of Massachusetts Lowell, where she heads the Robotics Lab, and is director of the New England Robotics Validation and Experimentation (NERVE) Center. Her research interests include human-robot interaction, multi-touch computing, robot autonomy, fostering trust of autonomous systems, evaluation methods for human-robot interaction, and the use of robots in K-12 education. Her research has been funded by the National Science Foundation, including a Career Award, the Army Research Office, Microsoft, and the National Institute of Standards and Technology. Dr. Yanco is the General Chair of the 2012 ACM/IEEE International Conference on Human-Robot Interaction. She served on the Executive Council of the Association for the Advancement of Artificial Intelligence (AAAI) from 2006-2009. Dr. Yanco was the PI of the NSF-funded development of Pyro, a Python-based robotics curriculum, which was selected as the Premier Courseware of 2005 by NEEDS. She has a PhD and MS in Computer Science from the Massachusetts Institute of Technology and a BA in Computer Science and Philosophy from Wellesley College. She has edited one book and published over 95 articles on her work. Dr. Yanco has received teaching awards from MIT and UMass Lowell.

Ellen Wetmore is an Assistant Professor of Art at UMass Lowell and has taught digital art and new media for 11 years at the college level. She has taught Artbotics, several digital media in art courses including Digital Foundations, and has received teaching awards and grants for her work in media studies. As a sculptor, she emerged in 2004 with her first Boston Sculptors show, and her work has explores surreal body transformations through interactive sculpture and video. She is the 2011 coordinator and juror for the New Media Caucus of the University Film and Video Association. Ms. Wetmore has also exhibited at the Dorsky Gallery in Long Island City, Currents Santa Fe, New Mexico, the Art Institute of Boston, Contemporary Sculpture at Chesterwood, the Sandwell Arts Trust in the West Midlands, UK, CologneOff, Cologne, Germany, the AiR Gallery in New York, the Women’s Caucus for the Arts, and Les Instants Video in Marseille, France. In 2007, Wetmore’s Land o’ Lactation was featured in the exhibition
Trainscape at the DeCordova Sculpture Park and Museum. She earned her M.F.A. in Sculpture and Sound Art from the School of the Museum of Fine Arts and Tufts University, a B.F.A. in Sculpture, and a B.A. in Philosophy and Art History from the University of Michigan.

Professor Hyun Ju Kim is a new media artist and an Assistant Professor at the Department of New Media in the Korean German Institute of Technology in South Korea, in which she is the founder and the director of Expanded Media Studio. As a former Assistant Professor of Art at UMass Lowell, Prof. Kim has been involved in developing the Artbotics program from its inception in collaboration with her colleagues in the Computer Science Department and the collaborators at the Revolving Museum. Kim’s research in New Media Art and the interdisciplinary collaboration of art and science has appeared in various journals and conference proceedings including the Journal of New Media Caucus, the Journal of the Korean Society of Media and Arts, SIGGRAPH 2007 Educators Program, ICRA 2011 Robots and Art Workshop, International Conference on the Arts and Society, and HCI Korea. She is the grant recipient of “Science Meets Arts” grant by the Korea Foundation for the Advancement of Science & Creativity (KOFAC) (2010, 2011) and “Interdisciplinary Arts” grant by Seoul Foundation for Arts and Culture. Kim studied Industrial Engineering in Pohang University of Science and Technology and got her M.F.A. in Computer Art at the Transmedia Department of Syracuse University.

Adam Norton is the manager of the New England Robotics Validation and Experimentation (NERVE) Center and the media and graphic designer for the Robotics Lab at UMass Lowell, both located in Lowell, MA. He is an instructor and core member of the Artbotics program, starting as a student in the pilot program. Adam has led multiple workshops and classes for middle school, high school, and college level students and educators, at both UMass Lowell and the Revolving Museum. He was a SPARK Ambassador at iRobot for their education initiative, “20 in 20 Robotics Roadshow.” He has also co-authored papers with his colleagues at the Robotics Lab on research topics regarding the design of innovative multi-touch software and telepresence robots. Adam earned his B.F.A. in fine art and graphic design from UMass Lowell.

7. Description

This book is proposed to be 400 pages long, featuring 4 contributors and several single page interviews, conducted by the authors. We will cover topics ranging from human-robot interaction, engaging students in the classroom, and recent developments in robotic art.

We will use many images to illustrate concepts and artworks. Diagrammatic illustrations can be done in house by two of the contributors for no fee. Several classroom photos are already acquired showing classroom process and final projects. We will need to research and acquire images of professional projects and hope to get these from the artists directly for an affordable fee. We will need your direction on the best methods here. We would like to reproduce artwork in color where possible. We do hope to keep the price affordable to encourage sales.
Given that this work seeks to synthesize a mix of writers on a cross-disciplinary topic, we understand the need for careful editing to successfully blend the topics together for a coherent and readable whole.

8. Outline

Preface

- Acknowledgements
- Artbotics history
- Book overview
- How to use this book

Part I: Artbotics Introduction

Chapter 1: Introduction to Artbotics

- 1.1 What is the value of combining art and computer science?
- 1.2 Art + Robotics = Artbotics
- 1.3 Outcomes/What you will learn from this book

Chapter 2: Understanding Interactivity

- 2.1 Introduction
- 2.2 Interactivity: Some Definitions

Chapter 3: Designing Interactivity

- 3.1 Three Elements of an Interactive Art System
- 3.2 Clear vs. Complex Interaction

Chapter 4: Technology in Contemporary Art

- 4.1 Brief history
- 4.2 Interactive art
- 4.3 Electronic art
- 4.4 Kinetic sculpture

Chapter 5: Robotics

- 5.1 Brief history
- 5.2 Robot morphologies
- 5.3 Uses of robots
- 5.4 Human-robot interaction

Chapter 6: Robotic Art

- 6.1 Examples
Part II: 2-D Design, Lights, and Sensors

Chapter 7: Two-Dimensional Design
- 7.1 Elements of 2-D design
- 7.2 Organization of Two-Dimensional Design Elements
- Lab: 2-D Artbotics Pattern Project – Part 1

Chapter 8: Lights, LEDs, and Power
- 8.1 What is a light bulb? What is an LED?
- 8.2 Power: Volts, Watts, Ohms, and Amps
- 8.3 Example projects using lights
- 8.4 Soldering
- 8.5 Series vs. Parallel Circuits
- Lab: 2-D Artbotics Pattern Project – Part 2

Chapter 9: Programming: Sequencing and Repetition
- 9.1 Samples of Code Performing an Identical Task
- 9.2 What is Pseudo Code?
- 9.3 Sequencing Commands
- 9.4 Looping
- Lab: 2-D Artbotics Pattern Project – Part 3

Chapter 10: Sensors
- 10.1 What is sensing? What is a sensor?
- 10.2 Examples of sensors in the world
- 10.3 Digital sensors
- 10.4 Analog sensors

Chapter 11: Programming: Reacting
- 11.1 Conditional Statements
- 11.2 Conditional Statements Inside of a Loop
- 11.3 Attraction and Reaction Modes
- Lab: 2-D Artbotics Pattern Project – Part 4

Part III: 3-D Design, Motors, Mechanisms, and Time

Chapter 12: Three-Dimensional Design
- 12.1 Elements of 3-D design
- 12.2 Language of materials
- Lab: 3-D Artbotics Project – Part 1
Chapter 13: Programming: Making Decisions
- 13.1 Multiple Conditions and Reactions
- 13.2 Decision Paths
- Lab: 3-D Arbotics Project – Part 2

Chapter 14: Motors
- 14.1 DC motors
- Lab: Robot Car Drawing
- 14.2 Torque and RPMs
- 14.3 Servo / stepper motors
- 14.4 Example projects using motors
- Lab: 3-D Arbotics Project – Part 3

Chapter 15: Mechanisms
- 15.1 Changing rotational movement into linear movement
- 15.2 Waving back and forth – Levers and Cranks
- 15.3 Rising and falling – Cams and Pulleys
- 15.4 Changing directions and speed – Gears and Bearings
- Lab: Kinetic sculpture using a mechanism – Part 1

Chapter 16: Actions Over Time
- 16.1 Introduction – Storytelling
- 16.2 Narrative Structure
- 16.3 Traditional Workflow of Narrative Content
- 16.4 Storytelling for Interactive Media Work
- 16.5 Programming an Interactive Sequence

Chapter 17: Programming: Functions and Variables
- 17.1 Functions
- 17.2 Variables as used to change actions
- Lab: Kinetic sculpture using a mechanism – Part 2

Chapter 18: Advanced Electronics
- 18.1 Relays
- 18.2 Adding external power
- 18.3 Resistors

Part IV: Project Process

Chapter 19: Brainstorming and Planning
- 19.1 Ways to brainstorm
- 19.2 Creating a theme for a set of projects
- 19.3 Planning for interactivity
Chapter 20: Prototyping and Testing
- 20.1 Materials for prototyping
- 20.2 How to solicit feedback on interaction

Chapter 21: Fabrication
- 21.1 Materials for fabrication
- 21.2 Planning for an exhibition

Chapter 22: Exhibition
- 22.1 Installation
- 22.2 Sustainability

Appendix: Resources
- Bibliography
- Resources for materials
- Index