CourseNo: ARCHA4823_001_2013_3

Meeting Location: FAYERWEATHER 202

Meeting Time: M 11:00A-02:00P

Instructor Information: Andrew O. Payne

GSAPP A4823 - Intelligent Systems / Interactive Architectures Syllabus

Fall 2013

Session A - 11:00AM - 2:00PM Monday (Lectures and Workshops)

Room: Fayerweather 202 (Computer Lab)

Instructor: Andrew O. Payne (andy@liftarchitects.com)

Teaching Assistant: TBA

Modern architects face the challenge of creating environments that fulfill the dual goals of *user satisfaction* and *energy performance*. Yet, many buildings consistently fail to meet these two needs. Recently, we have seen a shift toward the adoption of technology to produce *'smarter'* spaces to help meet our needs, yet smartness merely describes a level of interconnectedness, integration, and performative qualities required to meet personal or efficiency goals. *Intelligence*, on the other hand, conveys a capacity for learning, reasoning, and understanding. To meet the multi-objective functions listed above, building control strategies need to move beyond the realm of smartness and begin to display some form of intelligent adaptability - a recognition of the evolving external environmental conditions and the internal user demands. In essence, architecture needs to have the capacity to *learn* and *adapt* over time.

This class will focus on hardware and software prototyping techniques; primarily focusing on a wide range of sensing and actuation modalities in order to build novel interactive architectural prototypes. Using remote sensors, microcontrollers (Arduino), and actuators, we will build virtual and physical prototypes that can communicate with humans and the world around them. There will be particular emphasis on the concept

of *prototyping* - both digitally and physically - as a means to explore intelligent control strategies, material affects, and the parameters which effect dynamic systems.

A series of fast-paced lectures and technical workshops will expose students to topics relevant to this domain including: microcontrollers and programming, sensor technologies for interactive environments, mechanism design, robotics and motor control, fabrication methodologies, parametric design, computer vision and signal analysis, and interactive prototyping techniques. It is expected that by the end of the course, each student will have a range of skills capable of producing machines and prototypes that are configurable, sensate, and active.

Format: Each 3-hour session will consist of theoretical or technical lectures and hands-on demonstrations, as well as periodic pinups and presentations by students.

Prerequisites: While there are no prerequisites, some exposure to Grasshopper and/or programming is preferred.

Evaluation: Based on interim topic presentation, pinups, and the final interactive machine/prototype. Students will work in groups of 2-3 to complete assignments.

Keywords: Computation, Physical Computing, Embedded Systems, Fabrication, and Prototyping

Resources:

Software Requirements

· **Rhino 5.0** (32-bit or 64-bit versions)

· **Grasshopper (version 0.9.0056 or higher)**
http://download.rhino3d.com/en/Grasshopper/1.0/wip/rc/download/

· **Arduino IDE 1.0.5**
http://www.arduino.cc/en/Main/Software and http://arduino.cc/en/Guide/

· **Firefly 1.0068 (or higher)**
http://fireflyexperiments.com/download/

Hardware Requirements

It is expected that each student group (can be 2-3 per team) will need to purchase certain hardware devices in order to complete the tutorials/assignments presented in class. A list of required materials will be distributed on the first day of class, although a general estimate for materials would be around $100 for each group. Additional materials may need to be purchased depending on the complexity/design of each group's final project.

Class Date	Lecture Topic	Assignment Due	Workshop Topic
Tuesday Sept 3rd, 2013	Visual Studies Presentation		
Monday Sept 9th, 2013	Introduction		
Monday Sept 16th, 2013	Intro to Microcontrollers	Purchase Hardware	Arduino and Circuits
Monday Sept 23rd, 2013	Intro to Interactive Prototyping	Project Proposal	Intro to Firefly
Monday Sept 30th, 2013	Linkages, Kinetics, & Mechanisms		Motor Control
Monday Oct 7th, 2013	Sensor Technologies	Mid Review	Making Sensors
Monday Oct 14th, 2013	Computer Vision & Signal Analysis		Comp. Vision & Audio
Monday Oct 21st, 2013	Final Review	Final Review	

Assessment: Grades will be evaluated based on the formal and experimental ambition of the assignments, the conceptual clarity, cleverness, and precision of execution, and the mastery of technical concepts as evidenced by assignments, review interactions, and class participation.

20% Attendance and Participation

20% Completion of Tutorial Assignments

20% Mid Review, including in-progress prototype of final proposal

40% Final Review, including final prototype and simulation

Class Descriptions

September 9th, 2013 – Introduction

This class introduces the basic premises and parameters of the course, in particular the concept of Artificial General intelligence and it's progressions through the history of computation. We will look at early works such as the difference engine by Charles Babbage to cybernetics and feedback communications developed by Norbert Weiner to the founding of AI with projects like the general problem solver and Claude Shannon's mechanical mice and finally to the state of the art of AI today and what we can expect from intelligent machines in the future.

Technical Topics: Overview of software/hardware to be used during the semester.

Recommended Resources:

Eastman, C. 1972. "Adaptive-Conditional Architecture". In *Design Participation: Proceedings of the Design Research Society's Conference*: September 1971. London: Academy Editions.

Friedman, Y. 1972. "Information Processes for Participatory Design". In *Design Participation: Proceedings of the Design Research Society's Conference*: September 1971. London: Academy Editions.

Fox, M, and M. Kemp. 2009. *Interactive Architecture*. New York: Princeton Architectural Press.

Gershenfeld, N. 1999. *When Things Start to Think*. 1st ed. New York: Henry Holt.

Haque, U. 2007. "The Architectural Relevance of Gordon Pask". *Architectural Design* 77 (4): 54-61.

Ishii, H., and B. Ullmer. 1997. "Tangible Bits: Towards Seamless Interfaces Between People, Bits and Atoms". Paper presented at Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, GA.

Kurzweil, Ray. 2005. *The Singularity Is Near : When Humans Transcend*

Biology. New York: Viking.

Kurzweil, Ray. 2012. *How To Create A Mind: The Secret Of Human Thought Revealed* New York: Penguin Group, Inc.

Negroponte, N. 1975. *Soft Architecture Machines*. Cambridge: MIT press.

Payne, A. 2012. "IDE vs IPE: Toward an Interactive Prototyping Environment", in Jörg Peter Chat and Julian Adenauer (eds), *Prototype!*, Form + Zweck Verlag (Berlin), pp 172–82.

Sterk, T. E. 2003. "Building Upon Negroponte: A Hybridized Model of Control Suitable for Responsive Architecture". In *Proceedings of the 21st ECAADE Conference*. Graz, Austria, September, pp 407-414.

Sterk, T. E. 2003. "Responsive Architecture: User-Centered Interactions within the Hybridized Model of Control". In *Game Set and Match II*. Rotterdam: Episode Publishers.

Weiser, M. 1991. "The Computer For The 21st Century". in *Scientific American* 265 (3): 94-104.

September 16th, 2013 – Introduction to Microcontrollers

This class examines the rise of inexpensive, programmable microcontrollers for interactive devices - such as the Arduino. A microcontroller consists of a microchip on a circuit board with read-write capabilities, memory, inputs and outputs. The Arduino is an open-source electronics platform which is inexpensive, flexible, and easy to use and has had a profound impact on the fields of art, design, and human computer interaction over the last decade.

Technical Topics: Introduction to Arduino and microcontroller programming

Recommended Resources:

Banzi, M. 2008. *Getting Started with Arduino*. Sebastopol: Make Books.

Gibb, A. 2010. *New Media Art, Design, and the Arduino Microcontroller:*

A Malleable Tool. Available at: http://aliciagibb.com/thesis.

Igoe, T. 2007. *Making Things Talk: Practical Methods for Connecting Physical Objects*. Sebastopol: O'Reilly Media.

Noble, J. 2009. *Programming Interactivity: A Designer's Guide to Processing, Arduino, and Open Frameworks*. Sebastopol: O'Reilly Media.

September 23rd, 2013 - Introduction to Interactive Prototyping

Prototyping is inherently iterative in nature. Massimo Banzi, one of the co-founders of the popular Arduino platform writes, "we strive to find a simpler and faster way to prototype in the cheapest possible way... It is a constant search for faster more powerful ways to build better prototypes". This philosophy touches on one of the primary objectives of the prototyping process which is to be able to design objects in a more fluid, cost effective manner. This class will introduce a visually oriented Interactive Prototyping Environment (IPE) called *Firefly* which tries to address the shortfalls of traditional prototyping paradigms by creating a more creative and streamlined prototyping process for designers.

Technical Topics: Introduction to the Firefly plug-in for Grasshopper.

Recommended Resources:

Johnson, J and N. Gattegno. 2011. 'Experiments in Live Modelling', *PRAXIS 13: Ecologics*. pp 45–7.

Payne, A. 2012. *Interactive Prototyping: The Firefly User's Guide*. Available at: http://fireflyexperiments.com/resources/

September 30th, 2013 - Linkages, Kinetics, and Mechanisms

Kinematics pertains to the motion of bodies in a mechanism and their structures are governed by certain specific geometric laws which prescribe how connected components must interact and operate. This class will examine historical kinematic models and mechanisms, while exploring more contemporary examples of robotics and kinetic machines.

Technical Topics: Introduction to Mechanisms and Motor Control.

Recommended Resources:

Kinematic Models for Design (Cornell University): http://kmoddl.library.cornell.edu/index.php

Linkage Mechanism Editor & Simulator: http://blog.rectorsquid.com/programming-projects/linkage-2-0/

Linkages and Mechanisms Typologies: http://www.robives.com/mechs

October 7th, 2013 - Sensor Technologies for Interactive Environments

This class will examine, in as broad a scope as possible, many different sensors technologies that are useful in various Human Computer Interaction (HCI) applications. Examples will demonstrate how to integrate and apply various sensor technologies to make a meaningful measurement of the physical world. The class will explore commercially available components, as well as do-it-yourself techniques for building your own sensing platforms.

Technical Topics: Introduction to Sensors, Making a Bend/Pressure Sensor.

Recommended Resources:

Fraden, J. 1993. *AIP Handbook Of Modern Sensors: Physics, Designs, And Applications*. Third Ed. Springer: New York. 2003.

Horowitz, P., and W. Hill. 1989. *The Art Of Electronics*. Cambridge University Press.

Scherz, P. 2006. *Practical Electronics For Inventors*. McGraw-Hill, Inc.

October 14th, 2013 - Computer Vision and Signal Analysis

Many data acquisition devices and analysis methods produce some sort of array of values of various dimensions, depending on the application. Capturing devices such as microphones and video cameras record data in a structured format, over time - creating a signal which can be analyzed for various patterns. This class will examine different signal analysis procedures and computer vision algorithms, and explore how these can be applied to make successful interactive devices and environments.

Technical Topics: Computer Vision and Audio Analysis

Recommended Resources:

Gleick, J. 2011. *The Information: A History, A Theory, A Flood*. Pantheon Publishers, First Ed.

October 21st, 2013 – Final Review