Informal Robotics / New paradigms for Design & Construction

Course #: SCI-6478
(Cross-listed course #: SEAS ES256)
Architecture Department
Seminar/ Workshop
4 credits - Limited enrollment
Friday 12-2pm EST

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Course Description

Today new materials and fabrication techniques are transforming the field of robotics. Rather than rigid metal parts connected by mechanical components, robots may now be made of folded paper, carbon laminates or soft gels. They may be formed fully integrated from a 2D or 3D printer rather than assembled from individual components. Light, compliant, highly customized – we are seeing the emergence of a new design paradigm.

Informal Robotics draws on cutting-edge research from leading labs, in particular, Harvard's Micro Robotics Laboratory which has created unique designs for ambulatory and flying robots, end-effectors, medical instruments and other applications. We will explore informal robotics from multiple perspectives, culminating with the design of original devices displaying animated intelligence in real-time. Going beyond traditional engineering approaches, we will also explore new opportunities for design at the product, architectural, and urban scales.

Course topics include:

+ *Kinematics:* overview of mechanism principles, design techniques for pop-ups, flat-folding origami structures, and soft mechanisms.
+ *Fabrication:* use of composite materials, laminated assembly techniques, self-folding, and integrated flexures.
+ *Hands-on techniques*: A Kit of Parts will be available to all enrolled students. With the kit, you can create a wide range of folding mechanisms that can be controlled by on-board miniature electronics (also included in the kit).
+ *Software and Simulation:* Software workshops will be offered on Autodesk's Fusion 360 and Grasshopper for the design parametric models for motion simulation and mechanical testing. There will be two pre-recorded workshops for each software platform (four total).
+ *Electronics and controls:* Three pre-recorded workshops will introduce the basics of electronics, including Arduino hardware and software, use of servo motors to actuate robotic prototypes, and introduction to sensing devices to guide motion and interact with the environment.

Format, prerequisites, evaluation:

Course will have weekly lectures, with a portion that will be pre-recorded in order to reserve at least one full hour of the class session for discussion and interaction between students and instructor. All workshops will be pre-recorded.

For the first half of the course there will be weekly assignments to create CAD models and simulations, and to produce test mechanisms using the Kit of Parts. In mid-March students will form groups to formulate a proposal for their final project, which will remain the focus of the class for the remainder of the semester.

Presentations and discussions of ongoing student work are integral to the course. Although there are no firm prerequisites, some knowledge of scripting and/or fabrication techniques is helpful. Evaluation will be based on completion of assignments and the final project.

Final projects may be virtual, physical or both. Projects can be tailored to meet the specific interests of each group and may range from bioinspired devices to imaginative interpretations applying robotic performance to a broader architectural context.

There will be a final review with invited jurors where groups will present their projects. In addition to presenting their completed project, groups should discuss process development (with animations, video, and photographs) and share the knowledge gained during production of their final piece.

Resources for fabricating customized final projects are not fully known at this point, but instructor is committed to supporting physical-making to the degree possible.

Course Schedule: The following schedule is a general outline of course scope and pace, and is subject to change at the instructors' discretion. Students should expect weekly deliverables.

Date	Lecture topics	Workshops	Assignments	Milestones
29-Jan	Course intro robotic overview (traditional vs. informal) bioinspiration as design strategy design context - the parameters of movement	Fusion 1	Assignment #1 fusion model 1 TBD	
5-Feb	2D Mechanism design overview of mechanism types, link & joint types Gruebler's equation for planar mechanisms Relation between linkages vs. pop-up mechanisms	Fusion 2	Assignment #2 fusion model 2 TBD	
12-Feb	Folding mechanisms typologies - origami, flat-folding, laminated Prismatic mechanisms kinematic modelling self-folding strategies panel & hinge construction / material thickness	Grasshopper 1	Assignment #3 assemble mechanism with kit	KIT OF PARTS RECEIVED
19-Feb	Designing Robotic configurations case studies DOF analysis case study - prismatic leg	Controls 1	Assignment #4 Robotic appendage - physical or virtual	
26-Feb	Fabrication & Actuation force transfer strategies integration of actuator w robot mechanical degrees of freedom relative to axes of control thick origami compliance & use of flexures	Grasshopper 2	Assignment #5 full robotic configuration - body + appendages individual pitch for final project	FORM PROJECT GROUPS

5-Mar	Soft robotics Guest lecture (Lara Tomholt) inflatable actuation strategies	Controls 2	Assignment #6 actuate Robotic configuration Present proposal for final project	
12-Mar	Bioinspiration topics robotic configurations (body/leg/end-effector) achieving biological function with design Device case studies for ambulation,flapping, flying, swimming, grasping	Controls 3	Assignment #7 Develop Robotic assembly as prototype for final project	PRESENT PROJECT PROPOSALS
19-Mar	**Spring Recess**			
26-Mar	Inflatable origami bellows theorem yoshimura buckling flexible polyhedra			
2-Apr	Applications & Case studies overview of robotic types (industrial, bioinspired) actuation strategies & drive types		Review Assignment #6	
9-Apr			project update	
16-Apr			project update	
23-Apr			project update	
Week of 3-May	Final Review			