• Overview of Interactive Architecture (From Object to Environment)

• Humanistic and Pragmatic Applications

• Precedents projects in Interactive Architecture (physical and tangible)

• Pedagogy (tools and methodologies)

• Environments (full-scale built examples - responsive behaviours)

• Past Student Models (similar to what they will be doing)

• Application Suggestions (brainstorming)
If a space would actively mediate our needs and the environment, its demand on physical resources could be slashed.

If it would transform to facilitate multi-uses, its function would be optimized.

If an environment would adapt to our desires, it would shape our experience.
A Definition of Interactive Architecture “I.A.”

• Human and Environmental Interaction
• Physical Means of Actuation
• Embedded Computational Infrastructures

Architectural solutions that can demonstrate responsive behaviors with respect to changing individual, social and environmental needs.
Human and Environmental Interaction:

• Person – Built Environment (local + remote)
• Person – Person (local + remote)
• Person – Exterior Environment (local + remote)
Physical Means of Actuation

The Role of Kinetics in Architecture

Physical
Spatial
Tangible
Embedded Computation Development

• Research Originating out of: Computer Science, Intelligent Environments
  • Highly tectonic: speech, gesture, motion, environment
  • The military, the elderly and handicapped

• Systems do not deal with architectural issues of space
• Many research initiatives: not being led by architects
• Research in a bubble: lack of architectural client involvement
Architectural Issues

Attributes

• Communicatively Intelligent
• Behaviorally Active
• Respond to Individual and Social Needs
• Provide Attachment to Place and Space

Affordances

• Spatial Sharing and Optimization
• Privacy and Public Zoning
• Thermal, Visual, and Acoustic Conditions
• Natural Daylight Articulation
• Physically (spatially) meet Changing Needs
• Adaptive to Environmental Conditions

Doing things that are impossible or very difficult for us to do
Humanistic and Pragmatic Applications
Serving Two Types of Needs: Humanistic & Pragmatic

- **Humanistic:** Sociology, psychology
  - Human behaviors, sensing of place, understanding of space, control to space and attachment (bonding) to space
Serving Two Types of Needs: Humanistic & Pragmatic

• Pragmatic: Adaptability and optimization
  • Safety, security, spatial efficiency and energy efficiency
Precedents projects in Interactive Architecture (physical and tangible)
In contrast to standard computerized homes that can be programmed to perform various functions, the crux of our project is to develop a home that essentially programs itself by observing the lifestyle and desires of the inhabitants, and learning to anticipate and accommodate their needs. The system we have developed controls basic residential comfort systems -- HVAC (heating, ventilation, and air conditioning), water heater, and interior lighting. The system monitors the environment, observes the actions taken by occupants (e.g., turning up the thermostat; turning on a particular configuration of lights), and it attempts to infer patterns in the environment that predict these actions. If the actions can be reliably anticipated, the system can perform the actions automatically, freeing the occupants from manual control of the home. A secondary consideration of the system is to conserve energy resources, when possible.

http://www.cs.colorado.edu/~mozer/house/
Interactive Environments

• Exterior Walls
Christian Moeller
Kinetic Light
Frankfurt Germany
During the day, the perforated surface of the sheet metal, which is in front of the blue facade of the building, remains grey and reserved and only oscillates through the play of daylight. When dusk begins to fall, however, it transforms itself into blue-yellow floating figures, which change colors like a chameleon depending on their surroundings, the prevailing weather conditions.

http://users.design.ucla.edu/projects/arc/cm/cm/staticE/page3.html
SMART SHADE
Lance Hosey, Atmo/atelier Modern
The blind consists of a composite layer of zinc and steel, two metals with different thermal tendencies. Expansion and contraction of these sandwiched materials cause the blinds to curl up in winter and curve down in summer, varying the degree of sunlight in an interior depending on the time of year.
http://www.metropolismag.com/cda/story.php?artid=1705
BIX
realities: united architects
Lasipalatsi, Helsinki
BIX is a permanent light- and media installation for the Kunsthaus Graz in Austria by realities: united architects from Berlin. A matrix of 930 fluorescent lamps is integrated into the eastern acrylic glass facade of the biomorphic building structure of the new Kunsthaus in Graz, Austria. Through the possibility to individually adjust the lamps’ brightness at an infinite variability with 20 frames/second images, films and animations can be displayed - the Kunsthaus' skin is transformed into a giant low resolution computer display.

http://bix.at/
Podium Light Wall
Kinecity
2005
The Podium Light Wall is located on the South and North facades of 7 World Trade Center. As people wander on the pavement below a strip of blue light gracefully follows them. This strip of blue light is 7 floors tall and is visible from Freedom Park. The Podium Wall accentuates the individual, and the patterns that are created as many pass by together. The project is an interactive design for James Carpenter Design Assoc. who were responsible for the physical design.
Dimensions: 180 foot wide by 80 foot tall, x 2
Method: Camera recognition technology
http://kinecity.com/7wtc/
For us it was clear from the beginning that whatever we do should involve people and should be an easily understandable message. We condensed the phenomenon that is New York into a short statement: "What makes New York special is its people; their kinetic and psychic energy creates beautiful things." We then visualized this in a poetic manner through the installation: The energy that radiates from people walking by causes the supernatural flowers to "bloom." The scheme literally transforms people’s presence and movement into an interactive light and sound event. We chose neon because of its good visibility both in daylight and at night.

http://www.idonline.com/imdr03/power.asp
Blinkenlights
Chaos Computer Club
2002
Celebrating its 20th anniversary the Chaos Computer Club has made a special present to itself and the city of Berlin. From September 12th, 2001 to February 23rd, 2002, the famous "Haus des Lehrers" (house of the teacher) office building at Berlin Alexanderplatz has been enhanced to become world's biggest interactive computer display: Blinkenlights (a term defined by the Jargon File).

The upper eight floors of the building were transformed in to a huge display by arranging 144 lamps behind the building's front windows. A computer controlled each of the lamps independently to produce a monochrome matrix of 18 times 8 pixels. During the night, a constantly growing number of animations could be seen. But there was an interactive component as well: you were able to play the old arcade classic Pong on the building using your mobile phone and you could place your own love letters on the screen as well.

http://www.blinkenlights.de/index.en.html
Interactive Environments

• Interior Walls
Plug and Play Electronic Walls and Ceilings

Makato Sei Watanabe
The Lighting Research Center and ASSIST

This flexible interior infrastructure that will integrate solid-state lighting with other building materials and systems. The system would make it as easy to redesign lighting as it to move furniture: no need to drill holes or call an electrician.

A prototype room has been built to showcase the concept. The ceiling and walls consist of thin LED-lighted panels that snap in and out of a modular electrical grid and provide different lighting distributions. The panels can be rearranged rapidly to cater to changing room layouts or personal preference. The LED panels are controlled by a touch-screen monitor mounted on the wall.

http://www.lrc.rpi.edu/programs/solidstate/ongoingprojects.asp?id=78
4d Pixel
4d Pixel
2004

4d pixel is a smart surface which physically reacts to your voice, music and can write relieveo letters. The dynamics of the moving wall is caused by an ingenius collaboration with the human interaction, magnet-technology and intelligent software.
The 4d pixels are connected to the human activity and functions as an interface. In this way an active, physical relation is made with the space and the visitor.
Currently 4d pixel is further developed as a large façade for a public building.
http://www.berlage-institute.nl/03_postgraduate/virtual-gallery-dean.html
Daniel Rosin
Mirrors

One of man's earliest technological inventions, mirrors have been loaded with meaning and myth from the
beginning. Mirrors have often been thought as objects of evil and many superstitions are linked to them. Sometimes
overlooked in the search for important technological developments, I believe that no other invention has had a more
significant impact on the way people perceive the world around them, and more importantly the way they perceive
themselves.

http://www.bitforms.com/artist_rozin.html
The Aegis Hyposurface
dECOi
This project was developed for a competition for an interactive art-work for the foyer of The Birmingham Hippodrome Theatre. The piece is a facetted metallic surface that has potential to deform physically in response to electronic stimuli from the environment (movement, sound, light, etc). Driven by a bed of 896 pneumatic pistons, the dynamic 'terrains' are generated as real-time calculations.
http://www.sial.rmit.edu.au/Projects/Aegis_Hyposurface.php
Reciprocal Space
2005
Ruairi Glynn
Essentially It is a physical space that responds to the actions of it's inhabitants creating Bio-Feedback Loops
It will force the inhabitants to respond and reassess their preconceived ideas of architectural space being fixed.
http://www.ruairiglynn.co.uk/reciprocalspace/
Recently, nARCHITECTS had also created the Party Wall for the SoHo gallery Artists Space. The installation created a variable boundary in the gallery, dividing visitors into different sides of the room. The 5 cm-thick foam panels connect to servo motors, proximity sensors as well as pulleys and cables that react when the sensors detect motion nearby. The motors exert pressure on the pulleys, lifting, depressing, expanding or compressing the foam into waves visitors can interact with.

www.narchitects.com
Aperture

Aperture is a facade installation with interactive and narrative displaying modes. Consisting of an iris diaphragm matrix, the facade's surface with its apertures' variable opening diameters is enriched by a dynamic translucency, that creates new imagery as well as a new channel for communication between inside and outside.

Working on the topic “intelligent surface/sensitive skin” for the Digital Media Class at the University of the Arts Berlin, concept and prototype were conceived by Frédéric Eyl and Gunnar Green. Support by Professor Joachim Sauter and Jussi Ängeslevä.  
http://www.fredericeyl.de/aperture/index.php?main=2&sub=1
Lights on the Web
Masaki Fujihata
Gifu, Japan
Masaki Fujihata set this panel of lights up at the Softopia building in Gifu, Japan. Users can turn the lights on and off. The lights are controlled by clicking directly on any bulb.
http://ford.ieor.berkeley.edu/hr/otherdevices.html#light_onNet
LIVING GLASS:
David Benjamin and Soo-in Yang, the Living
Slits cut into a polymer window behave like gills on a fish, letting fresh air inside a room when the carbon dioxide sensors are set off. Thin shape memory wires that run parallel to the slits contract when current passes through them, causing the slits to pull open.

http://www.metropolismag.com/cda/story.php?artid=1785
A proposal created for Vito Acconci's architecture company in New York. This system would be integrated into the United Bamboo storefront in Daikanyama, Tokyo. As customers tried on clothing in the store's mirror they would be given a choice to take a picture of themselves. This image would then be uploaded to a queue of other customer's images and projected on a display system at the front of the store. The customer then becomes like a United Bamboo 'model' and other customers get to see what 'normal' people look like in the store's clothing.

Remote Home
Tobi Schneidler/smart studio
The RemoteHome is a flat share that will exist in two distant cities at the same time: London and Berlin. Both spaces are electronically connected through the Internet, to turn furniture and architectural elements into tangible and sensual means of communication. Sensory and kinetic devices, as well as an interactive light installation allow for the exchange between this remotely living group of friends. A mobile wireless artefact, in the shape of a transforming interactive bag, can be taken on journeys to stay emotionally in touch with the RemoteHome.
http://www.remotehome.org/
Interactive Dress
James Clar
Milan Triennale
Part of the exhibition "Dressing Ourselves" which took 50 different architects and artists (not fashion designers) and allowed them to create a dress in their signature style. A collaboration with New York architecture company Hariri+Hariri who's architectural designs are very tech-y, we integrated the Flexgrid bendable display system into their dress to create a reactive fashion piece. Depending on how viewers talked to the dress, different animations would appear, creating the sense that the clothes have a life of their own.
Interactive Environments

• Interactive Floors
Dynamic Terrain
DYTE
Dynamic Terrain is a dynamic architectonic surface. It demonstrates a possible future of an interactive system that forms our surroundings depending on the action taken by the user. It wants to be a creature that we communicate to and play with. It functions as a skin that holds the human body in a dynamic and creative way. It is an area in which to experience the mix of digital and physical space. It is a surface without a fixed form, it’s form is virtual, and therefore adjustable and erasable. The software provides spatial possibilities that are translated in real time to the physical shape.
http://www.janisland.com/DYTE.htm
EnterActive (11th & Flower)
2005
Electroland
Activities on the walkway trigger lights on the façade. People see their reactions in real-time.
http://electroland.net/flash.php
Sensacell

The Sensacell system is a human interface technology. It is ideal for smart architecture, interactive multimedia, retail entertainment, and a host of exciting new applications. Sensacell modules can be assembled to form interactive sensor surfaces of any size or shape from a single module to 1000’s of square feet, providing absolute sensing resolution down to 3 inches or better. Sensacell is a clever combination of advanced sensors, smart-networking technology and solid state LED lighting. The sensors can detect people up to 6’ away through any non-conductive material.

http://www.sensacell.com/
Suddenly, floor cells illuminated in seven different colors animate visitors to play with Ada. She expresses her feeling by means of light colors, sound intensification and image signals. Light fingers are one of Ada's output possibilities, by means of which she can touch visitors with beams of light. A RoBoser acts as Ada's voice. Add can dream in color and monochrome, by using stored images, image fade-ins of past and present and by linking up different past perceptions.

ADA Sedus
The Ada room interacts both with individual persons and groups of visitors. Access is obtained through three openings in a strip of mirrors, which are arranged in an oval shape and enclose the room up to a height of 2.6 metres. Above this, there is a projection surface all round the room, reaching up to a height of 5.5 metres. The room is characterized by the patented "floor cells" with a Plexiglass covering panel, whose surface seems endless due to the mirror. Current observations by Ada are projected onto the screen above. Ada expresses her feelings by means of processed and alienated images. Sometimes, she may want to bring two people in the room together or deliberately makes contact with a selected person.
Interactive Environments

• Other senses
The installation consists of a circular wooden platform of about 12 metres in diameter, on which is placed a structure consisting of 56 vertical steel posts, each 5.5 metres high. This "forest" of vertical steel posts represents the "interface" and the part of this light and sound sculpture which can be physically experienced.

Each of the steel posts is connected to an analogue-capacitive sensor system. In this "forest of posts", which thus responds to tactile impulses, visitors can evoke sounds which always result in a harmonic whole whatever the conceivable combination. All sound structures used in this installation were developed with the help of a "physical modeling system". The basic idea is to digitally simulate a physical model of the object which generates the sound, and then to place this model in a self-defined environment, in a "world", in which the object in its turn can be made to generate sound by means of a self-designed "impulse".

http://users.design.ucla.edu/projects/arc/cm/cm/staticE/page3.html
The seven audio pendulums are steel pipes, 11 meters long and painted blue. They are suspended in front of the building at 5 meter intervals. A video camera mounted outside transmits a picture of the audio pendulums swaying in the wind to a computer system, which then generates a digital image of the movement. The computer program thereby records the movements and transforms them into audio signals, the volume of which depends on the extent of the movement.

http://users.design.ucla.edu/projects/arc/cm/cm/staticE/page3.html
Pletts Hague
Reactive Spaces: Smell
This research project posits that if an architectural space could be precisely "tuned" with scents, it would be possible to create completely new ways of experiencing space. We believe that smell helps to alter our perception of a space: its size, its openness, its intimacy. We suggest that designed "scent environments" could, with great subtlety, define the mood of a place and the lifestyle of its occupants. [http://www.p-h.org.uk/](http://www.p-h.org.uk/)
Moody Mushroom Floor
Aester Architecture
1996
A smell/sound/light floor that develops moods and aspirations in response to the ways that people react to the individual outputs. The "mushroom" actions are determined by their goals -- each mushroom sets its own particular goals at any particular moment. These goals are given anthropomorphic labels like "spoilt brat" or "alluring" or "capricious" and define what the mushroom hopes to achieve. For example, a "sullen" mushroom will try and keep people away from it. However, it does not know how to do this -- it has to learn through trial and error which patterns of light, smell and sound are best for repelling people. If it is successful at being "sullen" it may well tend more often in the future to try to be "sullen". As a whole, the community of mushrooms begin to converge on particular behaviours after they have spent time in their environment.
http://www.haque.co.uk/moodymushroomfloor.php
Interactive Environments

• Spaces
The Fiber structure is a “non-static” structure. The Fiber structure bends in the wind and moves in an earthquake. But this movement is absorbed by active dampers. There are computer-controlled dampers which continually compensate for movement, so that the spaces devoted to human activities do not move. The peripheral structure moves in response to external forces, but the interior spaces are always still. If external forces are resisted, in the manner of conventional static structures, the structure collapses when the forces become too strong to resist. But the Fiber structure is an active structure. Since it guides external forces away by moving, it can handle stronger forces. Instead of fighting the external forces of nature, it is wiser to look for better results by guiding them away. Harmony instead of competition, coexistence with nature — this is one of the themes of the architecture and the city of the future.

The interior spaces are called bubbles. They are comprised of flexibly elastic materials and framework, and float supported by the active dampers of the Fiber structure. The bubbles change in shape according to the nature and conditions of activities in the interior. Sometimes they are a large mass, sometimes they are long and narrow, and sometimes they are compressed into a number of spaces. The surface of the bubbles is a “functional skin” that responds to the outside world.

The transparency of the surface materials, made of liquid crystals sandwiched in plastic, changes according to the activities in the interior. Alternatively, the skin can become a visual screen, communicating in real time with people on the street. The combination of flexible bubble spaces with the flexible Fiber structure enables an architecture that breathes like a living organism.

Son-O-House
NOX
2004

In the house-that-is-not-a-house we position 23 sensors at strategic spots to indirectly influence the music. This system of sounds, composed and programmed by sound artist Edwin van der Heide, is based on moiré effects of interference of closely related frequencies. As a visitor one does not influence the sound directly, which is so often the case with interactive art. One influences the real-time composition itself that generates the sounds. The score is an evolutionary memoryscape that develops with the traced behavior of the actual bodies in the space.

http://www.noxarch.com/flash_content/flash_conent.html
Proposing that lobbies will become highly integrated with urban spaces and more important than hotel rooms in the future, Lobbi_Ports investigates techniques for re-skinning existing high-rises where a newly designed curtain wall cantilevers off the building and suspends lobbies above the urban floor. The curtain wall and lobbies are designed from a modular system that incorporates structure and a lighting display infrastructure responding to events in the city and the hotel.

http://s-e-r-v-o.com/
Out of control - OLN

The public connects to the MUSCLE by sensors, and by input through sliders on the computer screen. The sensors are attached to the reference points of the construction. Coming closer to the sensors triggers a reaction of the MUSCLE as a whole. The public will discover within some minutes how the MUSCLE reacts on their actions, and soon the public starts to find a goal in the play. Another way to communicate with the MUSCLE is to operate the sliders on the computer screen. Bringing the slider to the right probably means that the selected area moves to right. But meanwhile ONL has programmed the MUSCLE to have a will of its own. The MUSCLE may not want to go there, and may try to crawl back. Then a true interaction starts, and the outcome of the transaction process may be unpredictable. The MUSCLE is the prototype for an environment that is slightly out of control. A prototype for a building which is pro-active rather than responsive and obedient to the user. Communication first starts when there are two pro-active parties involved. The ultimate goal is to develop an individual character for the MUSCLE during its 3 month performance at the Centre Pompidou.

Muscle Body  
Onl/Hyperbody Research Group  
2005

The MuscleBody project consists of a fully kinetic and interactive architecture that is a full-scale prototype of an interior space. The project is an architectural body that consists of a continuous skin that incorporates all its architectural properties and makes no categorical distinctions such as floor, wall, ceiling, door. The interaction between the MuscleBody and its players (the people that have entered the interior space) causes the MuscleBody to change its shape, its degrees of transparency and the sound that it generates.

To activate the MuscleBody information is abstracted from the behaviour of its players in real-time by a number of pressure and proximity sensors that are imbedded in the skin. The game-software VirTools is used for organizing the real-time relations between the input received by the sensors and the output consisting of the behaviour of the muscles and the generated sound.

http://www.protospace.bk.tudelft.nl/live/pagina.jsp?id=561cc397-e253-4fd8-8620-218ca9586807&lang=nl
Muscle Reconfigured
Onl/Hyperbody Research Group
2004
The Strip is visualized as a three dimensional section in space, which is completely programmed to respond to human occupants through its sensing, processing and actuating enhancements. The notion of transforming everyday utilitarian space into a living organism, which augments itself through time to cater to its inhabitants, places the user in the foreground hence completely reversing the conventional ICT based scenario where the user has to adapt to the IT enhanced object. The installation hence is conceived as an experiment in inculcating Ambient intelligence with a human centric computing component engrained within.

http://www.protospace.bk.tudelft.nl/live/pagina.jsp?id=7482d898-a5e8-49c2-a00b-b798a29972a9&lang=nl
E-motive House

Programmable Structure

The structure is a weaving loom between a hard and a soft structure. The hard structure consists of massive wooden beams, and the soft structure are long-shaped inflatable chambers between the wooden beams. In this way, the chambers can expand and shrink to give a global shape to the emotive house. The total construction is being shaped by a spatial structure of hydraulic cylinders which are cooperating to follow or cause shape-movements. The hard structure on the exterior is covered with photovoltaic cells to generate electricity. The beams are connected with each other with pneumatic muscles, which can be contracted and relaxed. The technical challenge lies in the weaving loom of the programmable actuators and the hard structure, and in the cooperation between those actuators. They all have to work together like a flock. The scripts that need to be written are based on some simple rules for flocking behavior. The mathematical rules of behavior are known, but are never applied on structural parts.
Meta-Morphic Architecture
Miles Kemp
http://www.metamorph.com
It is called remote home, and tests the mediation of two small architectural spaces into each other. It was set up at the Fisher gallery in Seattle. The Interactive Lounge Table in London and the Sound Shaft in Berlin - disassembled mouse and keyboard. The Lounge table picks up a responsive media projection that follows its movement and shifts music to the other side when touched.

Online Robots and Cameras
Berkeley
50 Documented Cameras and robots that are controllable via the internet
http://ford.ieor.berkeley.edu/ir/
Environments
(full-scale built examples responsive behaviours)
Michael Fox @ ArtCenter
Interactive Restaurant
Michael Fox @ ArtCenter
Interactive spa : ispa
Pedagogy (tools and methodologies)
New Modes of Designing

Tools and Heuristics:
Understanding System Attributes w/ Goal of Communication

• Virtual Modeling
• Physical modeling
• CNC fabrication
• Robotics
• Prototyping
New Modes of Designing

• Virtual Modeling (Simulation VS Visualization)
• Communication to problem-solve / communication to convey design intent
New Modes of Designing

- Physical Modeling
New Modes of Designing

• CNC Fabrication
New Modes of Designing

- Robotics
**New Modes of Designing**

- Prototyping
Past Student Models / Prototyping
Interactive modeling:

• \textbf{PHYSICAL MODELING OF MOTION}
Interactive modeling:

*PHYSICAL MODELING OF MOTION*
Interactive modeling:

- **Physical Modeling of Motion**
Interactive modeling:

**Physical modeling of motion**
Interactive modeling:

• **PHYSICAL MODELING OF MOTION**
Interactive modeling:

- PHYSICAL MODELING OF MOTION
Interactive modeling:

• Adding a means of actuation
Interactive modeling:

• Adding a means of actuation
Interactive modeling:

- Adding a means of actuation

Arm Movie
Bird Movie
Koi Pond Movie