CYBERNETIC WORKSHOP
Performing Energy Conscious Prototypes
Unit 8 - CHORA, London Metropolitan University, London, UK
25. February - 5. March 2010
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Participants

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Introduction

This workshop provides a platform to assess some of the assumptions we have of architectural production through the lessons of cybernetics. The most significant of these is a reconsideration of the role of models and modeling in the architectural design process.

The architectural model is at once a means for understanding the architectural “whole”- its 3 dimensional totality- as well a device for visualizing and studying its effects within a context. Modeling on the other hand is the activity of abstracting the complexity of reality in order to make it legible and workable in the design process.
The problem that we face with the conventional tools of architectural design is that the complexity we witness in reality is so reduced by the tools of modeling and models that it results in oversimplifications which confuse rather than enlighten problems.

Cybernetics has some lessons to offer in the modeling of complexity which can be instructive. The first is feedback which explains that any result of an action becomes an input for a subsequent action. This problematizes our linear understanding of cause and effect and instead presents it as a circular process. The significance of this is that complexity can be modeled through circular causality and therefore represented and simulated. A second lesson is that feedback can be regulated and steered so that it can yield favorable or surprising results. This ability to perform complexity provides an alternative method for constructing models; as cybernetic machines. As such the model doesn’t represent but performs.

In the following pages students were asked to adopt specific cybernetic concepts from cyberneticians W. Ross Ashby, Stafford Beer and Gordon Pask and use them to develop performative models. These act as manifolds to study action and response within different systems of the student’s choosing. What emerges from these experiments is that they elucidate the behavior of systems rather than their form, which provides insight into how they can be performed in reality.

Omar Khan
Homeostat machine by William Ross Ashby.

An adaptive ultrastable system, consisting of four interconnected Royal Air Force bomb control units.

Each unit reacts on all the others.
Cybernetics
By Nicola Nacona

Cybernetics comes from a Greek word meaning “the art of steering”. It is about having a goal and taking action to achieve that goal. Knowing whether the goal is being reached (or at least getting closer to it) requires “feedback”, a concept that comes from cybernetics. Practitioners of cybernetics use models of organizations, feedback, goals, and conversation to understand the capacity and limits of any system (technological, biological, or social); they consider powerful descriptions as the most important result. Cybernetics as a concept in society has been around at least since Plato used it to refer to government.
Homeostat machine
by William Ross Ashby.

Wiring diagram of one homeostat element.
The term itself began its rise to popularity in 1947 when Norbert Wiener used it to name a discipline apart from, but touching upon, such established disciplines as electrical engineering, mathematics, biology, neurophysiology, anthropology, and psychology. Wiener, adapted a Greek word meaning “the art of steering” to evoke the rich interaction of goals, predictions, actions, feedback, and response in systems of all kinds. Early applications in the control of physical systems (aiming artillery, designing electrical circuits, and maneuvering simple robots) clarified the fundamental roles of these concepts in engineering; but the relevance to social systems and the softer sciences was also clear from the start.

Early cybernetic researchers quickly realized that their “science of observed systems” cannot be divorced from “a science of observing systems” — because it is we who observe. The cybernetic approach is centrally concerned with this unavoidable limitation of what we can know: our own subjectivity. In this way cybernetics is aptly called “applied epistemology”. At minimum, its utility is the production of useful descriptions, and, specifically, descriptions that include the observer in the description. The shift of interest in cybernetics from “observed systems” — physical systems such as thermostats or complex auto-pilots — to “observing systems” — language-oriented systems such as science or social systems — explicitly incorporates the observer into the description, while maintaining a foundation in feedback, goals, and information. It applies the cybernetic frame to the process of cybernetics itself. This shift is often characterized as a transition from ‘first-order cybernetics’ to ‘second-order cybernetics.'
The [Black and Grey Water Treatment] prototype is one of the 3 elements which comprise my final thesis project - [Community Hub] Urban Prototype.

The water treatment system uses natural processes, to treat waste water locally for it to be reused by the same catchment group. The treatment system is dependant on several variables which need to work in balance for the system to succeed. These variables are; population figures for the catchment group, waste water volume produced by the population, the efficiency of water use of their appliances, the amount of space (hub land) which is available for the water treatment, and the capacity of the water treatment infrastructure.
System ‘R’ System ‘S’

S: A system which treats black & grey water volumes

The essential variables on which S volumes depend are:
1: R (production of the waste water)
2: The capacity of the treatment units
3: Hub land area available

Due to the nature of the treatment infrastructure, (which can increase treatment volumes in steps, not small increments) S is a step function.

R: A system which produces volumes of black & grey water

R is based on environment variables which change over time;
1: Population numbers
2: Water Use Efficiency

The environmental variables can vary in slow increments or in steps.

Ashby: Ultra Stable System

Ashby’s diagram as a Gray Water Treatment Cybernetic Machine
W. Ross Ashby’s Chapter on ‘The Ultrastable System’, from ‘Design For A Brain’, (1954) defines Veto Theorem: That the whole system can have as states of equilibrium only such states as allow a state of equilibrium in both the essential variables and S. Where S is a system within the whole. Ashby also defines variables in terms of different types of functions, depending on the nature of the rate of change in that variable.

By defining the many variables relevant to the success of the water treatment system in terms of Ashby’s functions, I have translated the treatment system into a cybernetic diagram based on Ashby’s system diagram. Interpreting the new cybernetic diagram as a mechanical process, I have designed a cybernetic balancing model to manage the variables on which this system depends.

The performance of this balancing system model is dependent on the volumes of liquid – or functions which are added to it. In a scenario based on predicted events in Xiamen city, the model demonstrates when the system will fail. These results have contributed towards the design of the system – and my final thesis project – which can cope with the future urban fabric of Xiamen.
1: 2010 [Community Hub] prototype is introduced to Xiamen. The Urban Villages produce a fixed volume of waste water, the [BGT] capacity is built to clean an equivalent fixed volume of water.

2: China meets its water use targets as water efficiency in appliances improves. 
R decreases to reflect new water use. 
The fixed population now produce less waste water.

3: The first wave of New Developments has completed construction. 
There is a resultant large and sudden increase in the local population which unbalances the system.

4: The capacity of the nearest [BGT] loops to the New Developments need to increase in water treatment capacity in order to satisfy the waste treatment of the new residents.

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TIME-LINE

EVENT

1: 2010 [Community Hub] prototype is introduced to Xiamen. The Urban Villages produce a fixed volume of waste water, the [BGT] capacity is built to clean an equivalent fixed volume of water.

2: China meets its water use targets as water efficiency in appliances improves.
R decreases to reflect new water use.
The fixed population now produce less waste water.

3: The first wave of New Developments has completed construction.
There is a resultant large and sudden increase in the local population which unbalances the system.

4: The capacity of the nearest [BGT] loops to the New Developments need to increase in water treatment capacity in order to satisfy the waste treatment of the new residents.

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INPUT \( R \) or \( S \)

RESULT ON [COMMUNITY HUB]

\( R = S \) SYSTEM STABLE

\( R < S \) SYSTEM OVER-ENGINEERED

\( R > S \) SYSTEM FAILURE

\( R = S \) SYSTEM STABLE
The second wave of New Developments has completed construction. There is a resultant large and sudden increase in the local population which unbalances the system.

The capacity of the nearest [BGT] loops to the New Developments need to increase in water treatment capacity in order to satisfy the waste treatment of the new residents.

The final wave of New Developments is complete. The area now has reached its maximum residential population based on the land ratio regulations set by local government.

The [BGT] capacity is increased to cope with the final waste water volumes. The [BGT] expansion meets its limits when the Hub Land reaches its maximum capacity.
The part of my project I wished to explore through the cybernetic workshop was the relationship between the cooling towers and the thermal dynamics of the heat island. The dynamics of the heat island use the mechanics of convection as a cybernetic machine. Inputs of temperature change the form of this machine creating a new environment within the city.

To go about this I used heat sources in various combinations in a tank of water and then added die to revile the currents.
Stabilisation of system [A]
A stable system is formed in the upper centre of the two heat sources sitting on top of the heat island.

Strengthening of system [B]
System [B] is strengthened by the stabilisation of system [A] combined a subduction effect further strengthening system [B].

Start of state change
Loss of stability in convection system [A], caused by the strengthening of convection system [B] on the right side of the tank.

Start of system merger
Brake off of right lower part of convection system [A] this is the point where system [B] starts to combine with system [A].

Formation of Meta-system
The left section of convection system [A] is removed the top merging in to system [B] creating a meta-system.
I analyzed selected parts of the thermal system created by the position of the heat sources. From this I deduced that the most opportune place to site my cooling towers is at the periphery of a heat plume. This placement makes best use of the dynamics on the surface of the heat island forcing down cool air.

In the text An Approach to Cybernetics, Pask discusses the dynamics of state determined systems. How a system can move from one equilibrium to another. Whilst at equilibrium the system holds a specific behavior within a range of fluctuations. This behavior is markedly different from its state at another point of equilibrium. This effect is the same a thermal dynamic system the state and there for behavior of air is altered by the input of temperature. the input of temperate tips the system out of its original equilibrium and in to its new state.

A selection of images showing the progression of an experiment. This collection of images shows how competing systems become visible in the overall dynamic. It's the by-product of the comparison I'm exploiting with my cooling towers.
The cybernetic model derives from the density map that is illustrating how the transportation network is distributed.

Population density determines the number of network connections to each nodal point.

Once the model is set to an equilibrium state, the intensity of distribution can be designed with other factors that come into consideration and influence the distribution.
On the basis of the Self Organization idea proposed by Ross Ashby, the transport network cybernetic model can be seen as a machine that manages different density distributions. These distributions are a direct consequence of different states through which the model goes in order to reach equilibrium.

We start with the fact that systems in general go towards the equilibrium. Now most of a system’s states are non-equilibrial (if we exclude the extreme case of the system in neutral equilibrium). So in going from any state to one of the equilibria, the system is going from a larger number of states to a smaller.

In this way it is performing a selection, in the purely objective sense that it rejects some states, by leaving them, and retains a specific state, by sticking to it. Thus, as every determinate system goes to equilibrium, so does it’s selection.
Imagine this is the current network and distribution as it is right now in Xiamen. The model is at the original position, each nodal points [tags] rest accordingly to where there is no forces of input that has been introduced to change its dynamic movement.

An upward force is applied. Population increases.

A horizontal force is applied. Population spread to a new point.

A downward force is applied. Population decreases.
The cybernetic model shows a relationship between the factories for bamboo products and migrant workers, and how it changes in different situations.

This model works as an analogue calculator. Four tracks represent the manufacturing process for bamboo products including forest, yarn, textile and clothing factories. The figures under the each track demonstrate the total hectares of forest and factories for the area and the possible numbers of employees is shown on top of the tracks.
<table>
<thead>
<tr>
<th>Essential Values</th>
<th>Area of the factory (ha)</th>
<th>Number of employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yarn Factory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Textile Factory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothing Factory</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Ultrastable System

- Environment
- R: Essential Variables
- S: Organism
- (S1, S2)

- Acrylic strip (S1)
- Acrylic strip (S2)
- Twine (R)

First feedback loop
Second feedback loop
Limit
These figures will change depending on the different situations. For example, if a number of migrants grow, the areas for each production process need to be increased (image 2). When these numbers rise proportionally, all the products are consumed locally. On the other hand, if the forest is expanded larger in proportion to the factories, the surplus could be sold to other areas (image 3). A number of factories need to be increase if the forest continues to expand (image 4-7). However, this proportion changes when it reaches its limitation (image 8). The city will lack of lands as forest grows at the certain limit, and it would result in the reduction in the number of factories. Deforestation could also cause the same consequences (image 9-12).

This system follows Ashby’s ‘The Ultra-stable System’. It talks about how the organism’s reactions to the environment change inside and outside of the limits. This system has two feedback loops. The first one is an interaction between organism’s sensory and motor channels (R), and environment. The organism has a variety of possible reactions (S) which have a range of values and are not fixed throughout. The reactions would have different results whether or not it is within physiological limits (Essential Values). For example, a kitten would show overt reaction to a fire (within the limit) and this will result in a value of S1. When the kitten is burnt (outside of the limit), it will lead a value of S2. The second feedback loop works with the interaction between organism and environment. The result of the first feedback loop determines whether it is within or outside of the limit and it will affect a variety of possible reactions with different values. These reactions will affect the organism’s behavior.

The cybernetic model shows different pattern of the materials created by different environments. The patterns are affected by a materiality of acrylic strips and their tracks. Acrylic strips (S1 and S2) responses to the different situations and S1 indicates the essential values (numbers of workers and areas of forest/factories). They are flexible within the limit (image 3-4) and as it reaches the limit, they follow the other
side of movement (image 4-6). They start to show different movements as it reaches the limit of the environment (image 7-9) and they change the shapes according to the change. The twine also follows depends on the environments. The proportion of R1, R2 and R3 maintains the balance when the forests and factories expand proportionally (image 2). However once they increase/decrease disproportionally, it loses the balance (image 3-13). S2 contains larger area when it is balanced and, it indicates an increase in the amounts of import/export of the products as it gets smaller.
In the cybernetic workshop I explore the **flexible and deformable property of a grid floating on the water**.

The starting point of my project is considering the sea as the main scenario to explore a new type of utopian living: an energy surface that reacts to the environment and organizes a food production network (Fish farming). Therefore, with this performative model (1st order cybernetic model) I am trying to design a surfaces that reacts to environmental changes, sun, wind and water:

A PHYSICALLY TRANSFORMED SURFACE.
THEORY

Reflexive Architecture
"Reflexive Architecture machines envisions architecture that is self-organizing, capable of transforming itself in response to changes in its environment or use. It re-imagines how we shape and assemble conventional materials, like rubber, plastic, and wood through a combination of material and computational processes to develop more complex relations between parts and wholes. This fundamentally challenges the static nature of conventional building materials and sensitizes them to the ephemeral and dynamic qualities of environmental conditions like heat, moisture, air chemistry and gravity. Omar khan’s gravity Screens and Open columns explore the possibilities offered by elastomers for developing an organically kinetic architecture. They use the unique quality of this material to build collapsible and expandable structures that move similar to plants and respond to information gathered by electronic sensors."

OMAR KHAN’S WORK

Self-organizing System
"Now, the kind of system we do have, when we do talk about it as a self-organizing system, is a system in which the elementary particles we are dealing with are not the elementary particles with which a physicist will commonly deal. These are replaced with unitary elements which may be considered to be automata, players, decision makers,
“neurons” or .the like. They can go “Poop I” and send a signal to another, the implication of the signal being that the state of some remote element is changed by the fact that this one goes “Poop!!”

GORDON PASK, A PROPOSED REVOLUTIONARY MODEL.

“The role of the architect... I think, is not so much to design a city or a building, as to catalyse them: to act that they may evolve” GORDON PASK

Variety

“And we can anticipate real interaction (as opposed to the action and reaction that is so often, currently, dressed up as interaction) that will occur in the space of between: the space of CyberSpace and the InterNET, the space where the architect can act in the InterNET as (s)he acts currently in architectural space. A space formed by and forming, as always, action. Space defined but not confined by action, but a thorough interaction. Architects will make spaces and places for the events of conversation - Cyber-Spaces. The space is between; the action is interaction; the form is the event; the result is the occasion; the place is the interface - but is not grounded: the place moves with us. All in the between and through interaction.

... Our lives have become unmanageable. In that lies the necessity of our freedom and our humility.”

GLANVILLE. UNMANAGEABLE VARIETY
DESIGNING FREEDOM

So we need to define architecture as an intelligent machine, a system organised in such a way as to meet the demands of surviving in the changing environment: From the static to DYNAMIC qualities of environmental conditions of the Xiamen bay. My model will be the grid that organises my program and transforms itself in response to changes in its environment.

Therefore, my first model is built as a palying-table where a grid made of rubber band is located on the top whose movement is controlled under the table by wooden sticks that represent the water flows (image 01 and 02). This way you can see how this grid will move due to the changing currents from high tide to low tide, and this movement generates energy. (image 03 and 04). So, we can say that the energy generator movement is a horizontal movement of this grid due to the water currents.

But what happens if the movement is also VERTICAL??
I went trough different materials trying to find the best solution that responds to my needs (image 05). But what factor should define this vertical movement? the answer was fast, ENERGY. the surface will not only be continuously adapting to environmental changes but also to the energy consumption changes of the city of Xiamen.
CONCLUSION

My model is a system organized in such a way that not only survives to the environmental changes of the Xiamen bay, but also to the energy consumption of the city.

The surface is divided in different zones, each one with different color that relates to different uses and the energy consumption is represented by nails as the weight that pushes this surface down. (Image 06 and 07)

This dynamic surface’s behaviour reacts to the user’s energy consumption. If the citizen exceeds the energy use, the dynamic parts of the carpet will submerge and stay underwater creating energy and depriving the citizen of the use of this space. If the citizen reduces the consumption, the platforms will emerge and offer a new space for the city... Energy punishment!
The Gulangyu Passive Energy Prototype is designed to teach children about the harnessing and utilization of passive energy for use in a building; and done so in a didactic way (picking up from the Montessori Method of teaching).

Early in the project, I analyzed energy transfer efficiencies between different materials and technologies (see Earth sheet). In the Cybernetics workshop, my aim was to create a tool through which children could gain an understanding of these transfers and their efficiencies through a system.
The ‘Unthinkable Systems’ text introduces algorithms and heuristics. An algorithm is a detailed instruction: “to get to the top of the mountain take the path and go left when it forks...”. A heuristic is an unspecific instruction that leaves a lot of space for the participant to improvise: “to get to the top of the mountain walk in any direction as long as that direction leads up...”.

In this text, Beer shows us a “machine for doing heuristics”. Very simply, a machine presents the user with either a red or a green light illuminated at random but never together. The user can then “train” the machine to show either red or green lights more often by “punishing” it of “rewarding” it (by pressing the relevant button) towards their own preference. Alternatively, if you instructed that person to make the machine show red more often, they could then “punish it” whenever green was illuminated.

This user interaction for alternative outcomes lends this type of machine to realizing my aim of a didactic energy transfer efficiency tool.
ENERGY TRANSFER TOOL IN RELATION TO UNTHINKABLE SYSTEMS TEXT

“It is not usually too difficult to prescribe a class of goals, so that moving in some general direction will leave you better off (by some definite criterion) than you were before.”

Passive technologies depend upon the harnessing, transferring and reintroduction of energy in an efficient way in order to be useful.

Through the Energy Transfer Tool, different systems of transfer can be tested towards a different “class of goals”.

For example, the instruction “by varying cog sizes at each stage, construct a system with the least energy loss between stage one and stage three”.

A child then working with the machine will succeed when the first and third band read similar results on their respective scales. Failure will be indicated by a high reading on band one and a low reading on band three. Or vice versa.

Another possible “class of goals” could be combined with the first by saying, “by varying cog sizes at each stage, construct a system with the least energy loss between stage one and stage three while creating a slow transfer through stage two”. The child here will be successful with the same result as the first task, but only if band two is low on its scale. The task of course could be flipped and a fast transfer at stage two would be indicated by a high reading.

The instructor issues the user with an algorithm (by varying cog sizes at each stage, construct a system with the least energy loss between...). The user (child) then continues in a heuristic manner. They experiment until they reach the desired outcome.

“Alter the solution you are now using a little bit, and compare the outcome with the erstwhile outcome. If it is more profitable, adopt it. Go on like this until any variation you make leads to a worse result than you already have.”
PERFORMING THE TOOL

My “performers” were Joshua (5) and Samuel (7). After a quick explanation of the workings and the potential aims, I left them to experiment. Pleadingly they picked it up quickly. They tried a few different combinations of cogs at different stages and did come to realize that the three read outs from the bands have a correlation to the different setups of cogs. They exchanged cogs until they had the three biggest at each stage; boyish exuberance I think.

The Energy Transfer Tool.
There are three stages, input; transfer; output. Each stage has three available cogs, small; medium; large, which connect to rubber bands that can be read against their scale on the base. A high reading equals a high efficiency and vice versa.

Joshua works the input cog (the only ones with a handle to do so) and monitors the outcome. Samuel must restrain the third cog from popping out due to the incompetence of the machine’s maker. This does not affect the outcome.
ALL TIMBER PIECES TO BE DESIGNED IN CAD THEN EXTRUDE CUT.

AS THE GEARS WILL CHOOSE THEIR DISTANCE FROM THE RUBBER BAND, VARIOUS LENGTHS OF WOOES WILL BE NEEDED. SETTING NO PRE-TRAVEL IS PUT ON THE RUBBER BANDS.

- ALTHOUGH THE DISTANCE MAY NOT BE SIGNIFICANT, ANY VACUUM MAY BE ABLE TO BE DRAWN IN THE PRODUCTION OF THE GAP.

MATERIALS

MDF
Dowels
Springs
Metal eyelet or pop fixing
Metal alignment cup
Rubber band

Each stage will have
3 Gears - a large, a small, and a medium.

Each stage will be colour coded:
Red - inside, blue - left, yellow - cut-out - this tapers into circular grooves and organisation, which prevail in monuments.
GORDON PASK:

Architects=systems designers forced to take interests in the organizational properties of development, communication and control.

A structure exist primarily to perform a certain function. A building is a meaningful as a human environment perpetually interacting with its inhabitants on the one hand serving them on the other controlling their behavior.

Mutualism and functionalism shifts toward the form of structure and toward the design of dynamic not static entities; materials and methods come quite late in the design process.

A functional structure must be imaged as continually regulating its human inhabitants:
- a) it exists as part of an intention or plan
- b) in the context of its temporal extension, i.e. growth and development

Architecture is machine for living in, that acts as a tool for serving its inhabitants. A reactive and malleable and adaptive environment. The results can be very potent.

1) purpose of the system to provide a set of constraints that allow for certain desirable modes of evolution;
2) choice of basic environmental materials; selection of the invariants to be programmed into the system relevant to the environment dialogue; how the environment will adapt and learn; choice of a plan for adaptation and development
MODEL ASSESSMENT

A self-organizing system starts with its parts separated, i.e. the behavior of each state is independent of the other, then they act so that they change towards forming connections of some type.

As soon a relation between states A (unstretched and unstable) and B (stretched and stable) is formed, the conditional state of C and D create a necessary component of organization. Hence condition is related to communication, so that parts are defined to be organized when communication occurs between them. Communication also implies the existence of some constraints implemented in the system from E onward.

**A - C unstable to stable**

From E to H the parts of the system are interacting so that to achieve some given focal condition. The organization is neither
good nor bad, it is always relative to the context in which it’s applied. The system is self-organizing or self-connecting in the sense that it changes from parts separated to parts joined (knotted elastic bands).

**D - H linear causality with negative feedback**

Eventually the dynamic system generates equilibrium and stability around itself and further develop adaptation to its environmental disturbances (tension forces).

In I the system proposes its own essential variables while still preserving its existence and specialization within that particular environment.

The system is said to be circular = linear causality+feedback

I self organizing, circular causality with positive feedback.
The most adaptable aspect of the project which suited the cybernetic workshop was the actual dynamics of the energy producing system of the power kite. The power kite inherently retains many parameters which enable to observe relations between them as they change. These parameters are: wind speed, altitude at which the wind is caught, distance of tether, distance over land on the horizontal plane, distance in the air in the vertical plane, the square meters of the wind capturing surface, the number of kites, the number of kilowatts per hours produced, the angle of attack and finally the amount of people benefiting from it. The relation between the kite and people is however a crucial element of the project. Therefore the model aims to incorporate this interaction.
The Homeostat, Ross Ashby

The principle of the homeostat rests on the idea that a system can self-stabilise itself in order to respond to externalities. A well-known example of a homeostat is the human body's ability to control its internal temperature according to outside temperatures in order to keep organs at a stable temperature. We find here the idea of stability in motion. This example is transferred in this instance as a means to explore the relationship between the energy impact on the city associated to a cultural impact. The higher the energy output, the higher the willingness to embrace energy efficient systems.

Overall Model Performance

The model was approached on the basis of the kite's various movements. These movements depend on a list of numerical parameters which come to interact with each other. The model was conceived as an analogue computer which could visually represent the variations of numerical figures in order to observe the relation between these parameters.
Nutrient Flow Loops
Patrick Fryer

This cybernetic model was designed to quantify nutrient flows in an aquaponic plant growth system.

The trade in nutrients from fish food to fish, fish to water and water to plant roots is measured and altered depending on the crop type and its particular nutrient requirements or ‘uptake’.

It operates like an analogue computer; pins on the nutrient uptake gauge are altered before inputting the theoretical nutrients. The further up on the gauge the pin, the higher nutrient uptake that plant has. Physically on the model, this results in a tighter elastic band which is less flexible when pulled perpendicular.
Attached to the other side on the plant gauges are two non-elastic strings which connect to the final meter. This tells us the quantity of nutrients available after the plants have removed sufficiently for optimised growth.

The cycle is then run again with altered input levels and plant levels to optimise this nutrient exchange in a symbiotic balance.

I looked at the texts of Ross Ashby and his ideas of the self-regulating system as a basis for my concept. He speaks of “developing a theory of dynamics that does not observe parts and their interactions but treats the system as an un-analysed while”. This idea of treating a system as a whole is vital to aquaponics; the symbiosis between fish and plant must be studied as a whole rather than apart as they are dependant on each other. The system become self-regulating as it attenuates after each pass of the cycle in order to achieve a balance between input and uptake.

The model of this process used elasticity to differentiate between different plant’s nutrient requirements. In reality this was very difficult to measure on this scale but the concept of this was strong nonetheless. It enables the operator to twist the amount of nutrient they are putting into the system, alter the crop required and number of these and then calculate how much nutrient is left and therefore how much can run into the next channel system. This attenuation is where the operator would continue to use this model in a series to calculate the flows for a longer series of growth channels.
The input gauge is turned by hand; this one input pulls the series of elastic bands through the system until the end.

These show initial ideas, each trying to achieve an even scale and measurement system. The final choice was ideal as the measurement for each channel was even and it worked perfectly in a series.
This project is concerned with the proliferation of micro-economies and energy management systems, based on the cultivation of algae in the urban villages of Xiamen, China. The formation of a biofuel cottage industry, leads to an amalgamation into community based energy management hubs, which in turn affords an income to radically improve the housing and infrastructure of the locality. This in turn leads to the creation of a truly harmonious city/village symbiosis, an exemplar energy city.
I attempted to use a cybernetic analysis to model the placement of vertical connections within the development of new residential structures. This would model placement based on the inertia of added mass. As the mass of the new residential structure grew, so would the impetus for vertical movement increase. Thus a new vertical connection would be created at the local tipping point, rather than an arbitrarily designated location.

The model used terms and conditions developed in W. Ross Ashby’s ‘Principles of the Self Organising System’. Specifically the nature of a system that modifies itself progressively into an increasingly stable state where the component variables equal each other out to zero.

In the example of the inertial modeler, potential kinetic energy was created by way pouring of molten wax above mesh gauze. By limiting the available pathways, a self organising system was initiated to stabilise that potential kinetic energy revealing an analogous resolution for that of the real world model.
Resolution of different sizes of pathway resolved within the same area. Each pathway tended towards resolution in a manner of accordance with which had already been shown - in pathways of equivalent size.

The creation of this physical modelling was partnered with algorithmic computer modelling, in an attempt to model the totality of the proliferation of an algal economy.

Process of inertial modelling.

Process of initial inertial loading.