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INTRODUCTION

This report describes the results of a collaborative research project to develop a suite of low-tech sensors and actuators that might be useful for artists and architects working with interactive environments. With this project we hoped to consolidate a number of different approaches we had found ourselves taking in our own work and develop both a "kit-of-parts" and a more conceptual framework for producing such works.

We had often found during design development in the past that ideas had to be prototyped both quickly and cheaply; it was more important that such prototypes were functionally efficient rather than aesthetically perfect. Like many other artists and architects working in the field of interactive environments, in cutting costs and development time we often had to resort to a "low-tech" approach, rewiring keyboards to get pressure-pad input into computers, or using the monitor with light sensors and relays to get physical output from computers. We also found ourselves taking apart and reassembling (i.e. "hacking") bits of technology that were not connected to computers (for example the flashing stickers attached to mobile phones could be used to trigger light sensors when a phone call arrived).

We were certainly not alone in hacking technology to suit our purposes and we realised that it would be very useful for others in our fields to have a good outline of this approach and indication of the types of devices they might use. It also seemed important to describe ways that such things might be reassembled in a coherent interactive system. At the same time we wanted to align our approach with a general interest in "open source" design in art and architecture and to draw particularly on the application of "low-tech" hacking strategies to high-tech, but inexpensive, objects, toys and devices.

The original intention with the research project was to develop four prototypes. Although we weren't sure at the time precisely what we meant by these four categories, for the purposes of having a starting point we were hoping to develop a "sensor", an "actuator", a "power source" and a "wireless communicator". As we proceeded with the design development, however, it soon became clear that, depending on circumstance, "sensors" might also be considered "actuators"; "actuators" could in some cases be considered "power sources"; a "power source" with a switch was actually a type of "sensor"; and that many devices are considered "wireless" even though their wireless aspect might be the least interesting.

We had to develop, for ourselves as well as for the project, a conceptual framework within which we could define "inputs" and "outputs" to a system as well as the "comparator" that sits between them (drawing heavily on second-order cybernetic principles). Using such an approach, we were no longer limited to defining things solely in terms of single use (as the sensor/actuator approach tended to force us to do) but were able instead to define things based on whether we were looking at what was going in, or what was coming out of any particular device. Our aim in each case was to develop a precise set of instructions so that lay people could replicate the experiments with devices easily available at low cost.

By the end of the research we discovered that we had developed not four, but perhaps closer to forty different devices or arrangements (what we came to call "compound systems") and had a difficult time finally selecting which were the most important for the purposes of noting in detail in this report. In the process we had also clarified for ourselves the "types" of interaction and system that we tended to prefer which gave us good indication of ways to assemble and choreograph our subsystems as a whole system.

We hope now to release the contents of this report to a wider audience so that the ideas can be used, amended and redistributed.

LOW TECH

Artists and architects who want to experiment with interactive spaces and responsive systems, particularly on large, urban-scale projects, are often prevented from doing so because of the complexity, logistics or costs involved with such systems. Prototype research seems prohibitively expensive and the most interesting concepts and approaches remain on the drafting board until a suitable client/investor/sponsor is found. Alternative channels for financing and development need to be found; a solution is found in the combination of reusability and "low-tech".

New media artists and architects don't necessarily need the precision and accuracy that scientists usually do in order to explore the poetries of interaction. They therefore often do not require such sophisticated equipment in order to develop truly interesting interactive projects. They work well with the "making-the-best-of-what-we-have" approach, using artefacts at hand, and are comfortable with the idea of "hacking" existing technology (in the sense of taking it apart to understand how it works and putting it back together again, usually with improvements). In this way, it is possible to design interfaces, sensors, bio-feedback devices and actuators all using relatively simple technology that might even already exist in people's homes. In particular, inexpensive remote control toys are these days ripe for dismantling and reworking; kids walkie-talkies can be used to set up a simple wireless network; energy source for a simple interactive device could be generated from the movements and footsteps of people within a space.

One way to pursue this line of work is to develop a suite of low-tech sensors and interactive actuators that can be produced inexpensively from off-the-shelf toys and devices. These "hacked" devices can form part of "kit-of-parts" that new media artists and interactive architects could use for their interactive design projects.

As a first step towards a comprehensive set of such tools, we are presenting here an outline of devices we have hacked and techniques we have explored using off-the-shelf devices, gadgets and toys in simple responsive systems. Recently, such devices have become much cheaper. They often contain a range of sensors and actuators that are directly relevant and certainly useful for the development of interactive systems that artists and architects may be interested in. We explain what these devices are, how they are deconstructed and reconstructed and why this might be useful. In most cases the gadgets can be bought for less than £5; in some cases they are under £10; we have also included a couple of particularly useful devices that can usually be found for under £25. We also outline a conceptual system for understanding how to put together these instruments into an interactive environment.

CONTEXT

It is important to be aware of the context in which these toys exist and in which they are dismantled and re-appropriated.

Current movements in design, art and architecture explore the application of open source principles learned in software development to the collaborative creation of environments, experiences or objects. In computers there are different kinds of operating systems, ranging from Windows, thru Mac OS X and Unix to Linux. These operating systems differ not only in having different features and interfaces, they are also based on different ideas of openness. Linux is a type of operating system that falls under the category of "open source" - unlike other operating systems, the source code at the heart of the Linux system is open to anyone to view, modify and upgrade as necessary, with the requirement that any such revisions be equally "open" and available to all. To apply such a notion of "openness" to the design of spaces and objects requires two main strategies. The first is that such spaces and objects must somehow be open to all to be interpreted, inhabited, appropriated and redesigned. The second is that the tools for making these interpretations, inhabitations, appropriations and redesigns must be equally open.

Operating with low tech interfaces, sensors and actuators as we advocate here is one step closer to opening up the tools for appropriation and recombination to a wider audience and a wider production base. The advantage of working with low tech toys and devices is that very little specialist knowledge is required. It is perfect for a design process where imagination is in abundance but budgets are not!

It is important to be aware, however, that these inexpensive devices do come at a price, and it is not necessarily a price that we, in the West, have to pay: most of them are manufactured in China, in anonymous factories about which we know very little. The fact that it is possible to construct toys packed with sensors for relatively small amounts of money should give us cause for concern: it is clearly the factory worker him or herself who is bearing the brunt of this cost-reduction. From another socio-political perspective, it is relevant to note that the appropriation of low tech devices has also featured in recent well-publicised terrorist action. For example, in the Madrid bombings of 2004, it has been determined that at least some explosives were detonated by remote triggering of a mobile phone, using a technique that is familiar to many artists working with mobile devices.

As such, any invention using these devices will necessarily have a political dimension. We leave it to the readers of this guide to determine how much they want the knowledge of this to affect the work that they actually produce.

A CONCEPTUAL FRAMEWORK FOR PLANNING YOUR SYSTEM

For the purposes of this document, the SYSTEM refers to what you are building. A SUB-SYSTEM refers to a part of that system, perhaps just one or two components that have been attached together. The system you are building exists in an ENVIRONMENT.

Its components can be described in terms of the following categories:

- SENSORS receive input from the environment
- ACTUATORS send output back into the environment
- COMPARATORS sit between sensors and actuators, computing output variables according to single or (usually) multiple input variables
- FEEDBACK is the process by which output data re-enters a system through its sensors in such a way that this new input data is re-computed by the comparator

Your SYSTEM can be described as having a "goal" – this goal may be fluctuating according to any number of INPUT variables (e.g. time, sensor activity, randomness, etc.).

We like SYSTEMS that exhibit relatively complex behaviour. By this we mean that their goals appear to change over time relative to the state of the SYSTEM and may often change because of the presence or actions of people in the ENVIRONMENT. Their behaviour may at first seem a little unpredictable; we try to discern a pattern in the OUTPUTS, but just as we think we are getting close to understanding, the SYSTEM changes again, keeping us always intrigued. Finally, in our list of definitions, if a goal is fixed throughout a fixed loop then we call it a "first order system"; if the action of a loop changes the goal of another loop (usually recursively) then we call it a "second order system". Obviously, we like second order systems!

You will find that all the toys and gadgets we describe can be thought of on their own as SUB-SYSTEMS – they each have INPUTS, OUTPUTS and COMPARATORS. However, when they are hacked to sit in the SYSTEM that you are designing, they themselves function as SENSORS, ACTUATORS or COMPARATORS. Therefore, in our description of each toy or gadget, we also describe the various possible INPUTS and OUTPUTS that each one has, enabling you to interface it at whatever position you decide is best in your SYSTEM.

So that you can more easily navigate the various components we describe, whenever an entry refers to another entry, it will be noted in CAPITAL letters. For example, in the SOUND-RESPONSIVE CAT entry, we refer to both a LASER and a WALKIE-TALKIE. For more on how to connect those components through their own INPUTS and OUTPUTS simply navigate to their respective entries.

The first section (Compound Systems) describes arrangements of toys and devices that become functionally useful. The second section (Individual Components) describes specific procedures for the individual toys or devices that are assembled in the Compound Systems.

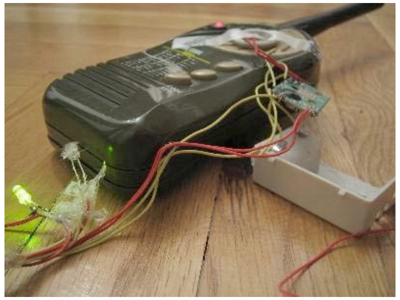
COMPOUND SYSTEMS

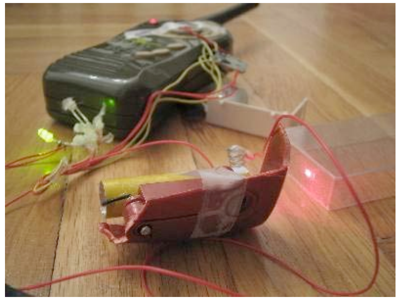
Arranging individual toys and gadgets to make useful devices

VOICE ACTIVATED REMOTE LASER

METHOD
WALKIE-TALKIE + CAT + LASER

The microphone of the CAT is placed on the speaker of a WALKIE-TALKIE (picking up sound from another distant walkie talkie). The LED output wires are connected via the RELAY INTERFACE to a LASER POINTER. So, here we have created a COMPOUND-SYSTEM where a remote sound from another environment can switch on a laser in this environment. We have left the green LED switched on in the photograph, but of course you can also snip it off to save battery life (after you are sure that it's all still working!).

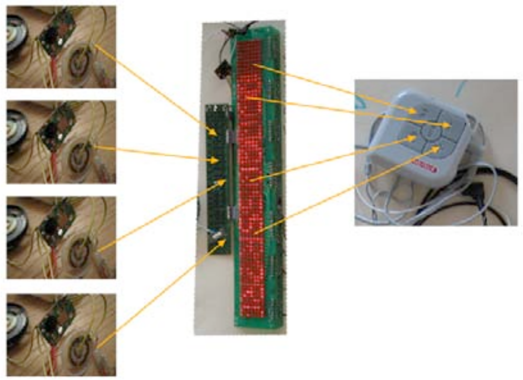




TOUCH TRIGGERED MULTI-SOUND (WITH COMPARATOR)

METHOD
CAT + LED MATRIX + MP3 PLAYER

Several CATS are attached to a number of different objects, but covered by material to reduce their sound-sensitivity (as such, they become ideal touch sensors). These are then connected to the LED MATRIX input while the output of the LED MATRIX sends signals to the controls of the MP3 PLAYER. Thus, by touching different objects one can trigger different audio patterns; the patterns depend on the order in which the objects were touched.



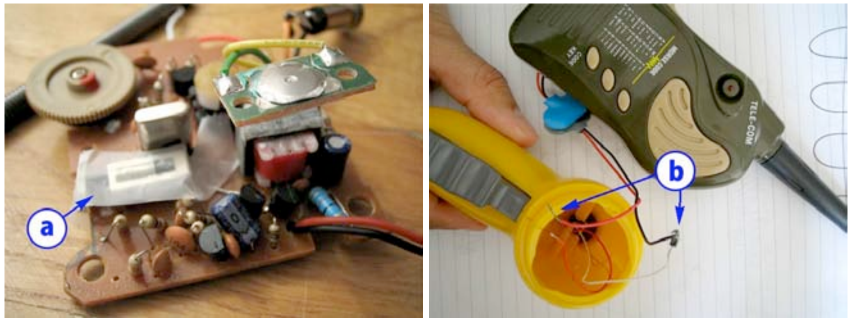
SELF-POWERED REMOTE STEP SENSOR

METHOD
TORCH + WALKIE-TALKIE + CAT

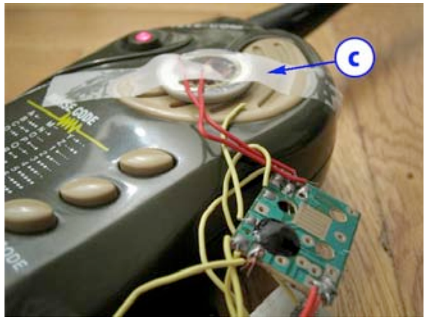
What it does
This COMPOUND-SYSTEM can be triggered by some mechanical force, for example people stepping on it, wind, or water pushing it, and it can send a signal via radio waves to a remote receiver, all without the need for batteries or electricity, since power is generated directly by the mechanical force. The other side of the COMPOUND-SYSTEM than receives the radio signal and triggers an action of your choice.

Start with the CAT, strip it to have its contact microphone and LED eyes open, we don't need the speakers here. Open one of the WALKIE-TALKIES, and remove its batteries, and note where they are connected to. Most WALKIE-TALKIES either have a Morse button that produces beeps – if yours has, close this button permanently, but in all cases close the button used to start speaking. Now take the TORCH and strip it to its lamp-power wires, and connect these to power the WALKIE-TALKIE (check polarity). Now we have a device the sends a radio signal once stepped on for example.

On the other end take the contact microphone of the CAT, and tape it on the speaker of the unopened WALKIE-TALKIE. Than the LED eyes of the CAT can be used for example to trigger through a RELAY almost any electronic device.



Tape the talk button of the WALKIE-TALKIE a and connect the torch power to the WALKIE-TALKIE battery compartment b

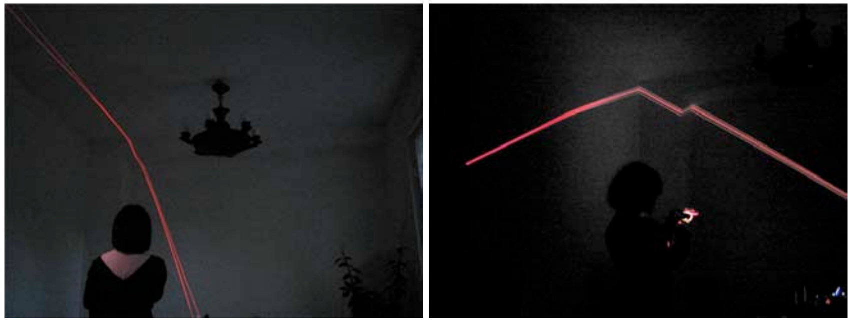


The CAT can listen to any noise from the WALKIE-TALKIE c

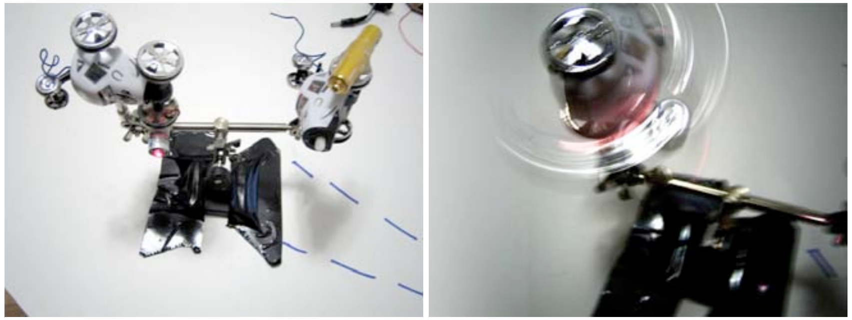
SPACE MAPPING LASER

METHOD
RC CAR + LASER POINTER

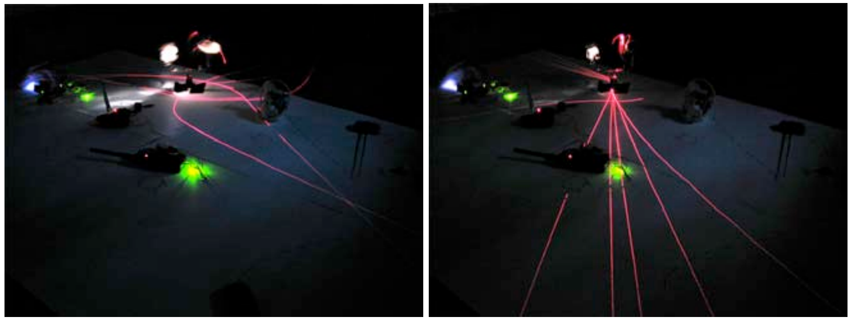
What it does
In a dark space, a fast rotating LASER POINTER can draw a perfect plane on the walls. Since it is a very basic shape, it can point out the geometry of the space when breaking in the corners. Using more than one axis for rotating this effect can be enhanced to morph complex repetitive shapes, while still staying sensitive to the borders of the space it inhabits.


Mapping the geometry of a dark space

How to put it together
This is very simple, no electrical tricks required. For the first option, just tape a LASER POINTER to the wheel of the RC CAR. If you prefer to have it interactive, simply connect a CAT to the RC CAR controller, and there you have a sound activated space framer. To reach a more complex shape drawn, either tape some RC CARS together to create a multi axis movement, or find RC CARS that multi axis rotation (originally intended for doing tricks)



Mounting the lasers on RC cars

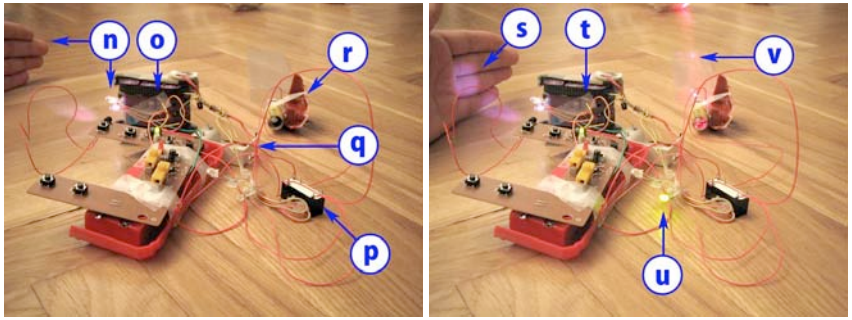


Drawing complex shapes

BODY TRIGGERED LASER

METHOD

TANK + CAT + RELAY + LASER

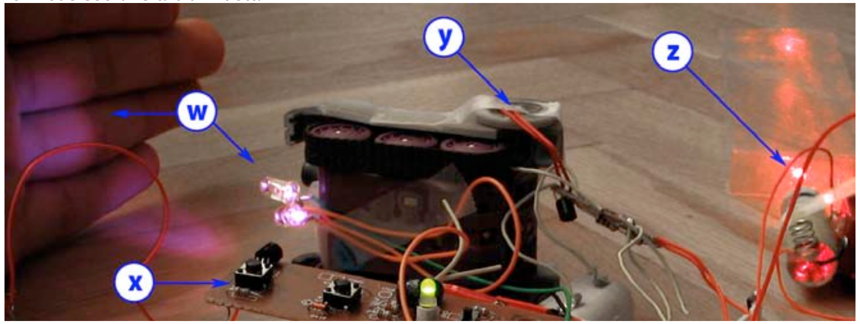


An interface and an action connected to the proximity sensor.

On the left, first, n shows the aligned infrared diodes and a hand approaching, o is the toy car lying on its side, q is a CAT toy that we use for interfacing, that should than trigger p RELAY, that should turn on r laser.

Now on the right, we see the hand getting closer and reflecting s the infrared light, that turns on the t cars engine, so it start to vibrate as well, which is used to trigger the CAT, turning on its u LED eyes and the RELAY at the same time, which is turning on the v laser.

Now let's see this a bit in detail.



w shows the two aligned infrared diodes, and their light reflected on the hand, x is the button we have connected earlier, y is the contact microphone of the CAT used here to pick up the engine movement action of the toy car, which CAT turns on a RELAY which RELAY turns on the z laser.

INDIVIDUAL TOYS AND GADGETS

Stripping devices for their basic inputs and outputs

RELAY

DESCRIPTION

The RELAY is one of the most important interface devices we use – it allows disparate devices to be connected without disrupting their respective power supplies and signals. A RELAY is essentially a powered "switch"; when it receives power at its INPUT, it closes a switch at its OUTPUT. This is the best way to trigger a device through another one because devices often have quite sensitive analogue electronics and connecting them directly to each other can have unpredictable (and at times destructive) effects. Used in almost every COMPOUND SYSTEM.

METHOD

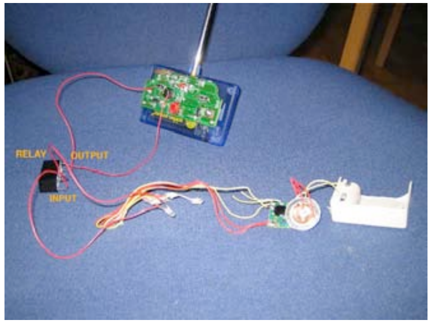
Connect the OUTPUT of your triggering device to the INPUT of the RELAY. Connect the INPUT of your triggered device (either in series with the power supply; by replacing its on-off switch; or by replacing any other action buttons – see for example MP3 PLAYER) to the OUTPUT of the RELAY. You may have to try several different arrangements of pin connections – some relays have 3 output pins, with a ground and 2 other that are alternately open and closed depending on input signal; others have 4 output pins and each pair is either open or closed (opposite to the other pair) when power is supplied to the input. You will generally need a low-power, low-voltage relay.

INPUT

electricity (digital) – usually 3v – 24v.

OUTPUT

switch (digital) – on-off output.



SOUND RESPONSIVE CAT also known as CAT

DESCRIPTION

This toy is useful in creating something that responds to sound or light touch. You might want to build something that switches on when you clap, or which triggers something else when loud footsteps sound through a room or which lights up when you stroke it.

METHOD

You require anything that does something else in response to sound; for example, a ball that rolls when you talk to it or a flower that dances in time to music. In our example, we have chosen a very cheap SOUND RESPONSIVE CAT, which flashes its eyes and makes a loud "meow" sound when there is a sound nearby or when it is stroked. You will take apart the toy, keeping the microphone in tact, and use the electrical output of its LEDs (or motors depending on what your toy is) to trigger something else.

INPUT
sound (analogue) – clapping, loud voice, furniture movement
touch (analogue) – stroking, jostling, footsteps

OUTPUT
light (digital) – LED eyes light up
sound – loud "meow" sound
electricity (digital) – a positive voltage across the wires leading to the eye LEDs

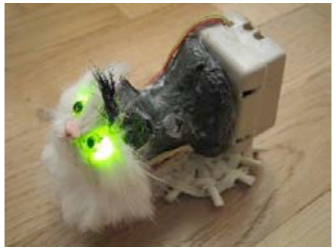


PROCEDURE

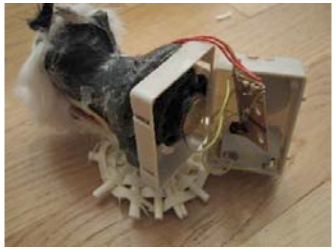
1. As with all toys, the packaging should be removed. Lifting the CAT out of its basket and raising its tail will reveal a plastic box at the back of the cat which contains the electronic components.

2. As you begin to skin the CAT, you will notice that it is built on a plastic core. Wires lead out of the plastic box. Be careful not to break them as you peel back the fur!

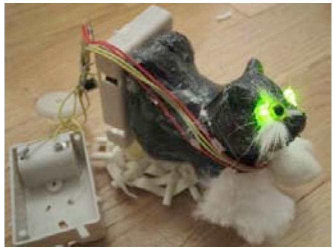
3. Remember to check repeatedly throughout any deconstruction process that you haven't mistakenly broken something or detached any wires. (This makes debugging a lot easier). Clap your hands! (If it still meows and lights up, then it's still working).



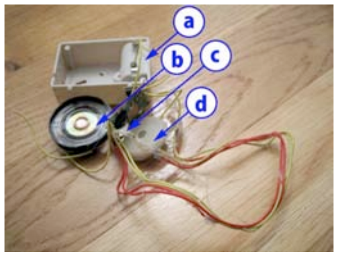
4. Carefully open the electronics housing.




5. And check again that everything is still working!

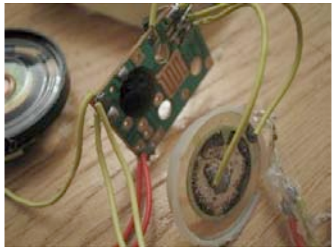


6. Once you have peeled off the LEDs from the head and completely removed the electronics from the bits of the cat that you don't need you can begin to identify the various components. Check it's still working…



a battery, b speakers, c LEDs, d microphone

7. Look closely and you will see the little integrated circuit that controls the CAT. It's the green board that all the wires and parts are attached to. What we are calling a microphone is not really a microphone – it's more of a vibration sensor. Since it is quite sensitive, it even picks up air vibrations (i.e. sound). Now, there are a few different things you can do with the components you have. On the INPUT side, either you can use it to pick up sound in the environment or you can use it to pick up sound directly from other devices. On the OUTPUT side either you can use it to create a flashing light ouput; or you can use it to create a meowing sound or, most interesting to us, you can use the voltage of the LED to trigger something else.




USAGE

The CAT, another one of our most useful devices, can be found in:

- SOUND ACTIVATED SPACE DEFINER using CAT + RC CAR + LASER
- PROXIMITY DEPENDENT LASER using TANK + CAT + LASER
- WIRELESS SELF-POWERED PRESSURE PAD using TORCH + WALKIE-TALKIE + CAT
- VOICE ACTIVATED REMOTE LASER using WALKIE-TALKIE + CAT + LASER

TORCH

DESCRIPTION

Recently, gadgets that are powered by winding or pushing have become cheap and commonplace. (You may also have heard about the wind-up radio, or the wind-up mobile phone charger). We can employ these devices as predatory power sources in our systems. Depending on how they are positioned and interfaced they can get power from hand movements, foot steps, the wind or water power.

METHOD

You require anything that has no battery and that generates its power through hand movements. We have used a hand-powered torch, which is powered by squeezing the trigger repeatedly, lighting up a cluster of LEDs. These LEDs can be by-passed to trigger or power other devices.

INPUT

movement(analog) – usually a pivot and flywheel

OUTPUT

light (digital) – LEDs light up
electricity (digital) – a positive voltage across the wires leading to the LEDs

PROCEDURE

1. The process for adapting the TORCH is relatively simple. However, great care must be taken not to damage the electricity generating system. Our recommendation would be to use the torch without dismantling the handle section – simply design your phsyical interface to move the existing handle in order to generate power. Then, having snipped off the LED light output, attach the wires directly to the power socket of the device you would like power. (You may alternatively use this voltage to trigger a RELAY, in turn triggering another device).

2. After ensuring that squeezing the handle still powers the device you will have to attach a custom-made device to make it into something useful. Below we show how it might be turned into a foot switch, powering something every time it is stepped on. A hinged foot plate depresses the handle; the handle also acts as a spring to reset the foot plate in its original position.

USAGE

The TORCH, is used in one of our favourite devices:

- SELF-POWERED REMOTE STEP SENSOR using TORCH + WALKIE-TALKIE + CAT

LED MATRIX

DESCRIPTION

The LED MATRIX is the device you might sometimes see in a shop window advertising current specials, or giving information about ongoing activities. Though they used to be quite expensive they are now much cheaper and can often be found for under £30. However, this device is one of the most expensive we have listed in our kit-of-parts – we include it because it is also one of the most useful. In one incarnation, it can output letters and words to its screen based on triggers to its input; it can also function as a sort of device "sequencer" triggering successive devices in a pre-programmed pattern (each device being connected to a particular LED output); and finally, in another incarnation it can be used as a complex COMPARATOR within a second order system which results in the kind of intriguing behaviour we are most interested in.

METHOD

Ideally you will use an LED MATRIX that has a keypad for entering in custom-made messages. As an OUTPUT device, you will use the LED OUTPUT of individual LEDs in its screen to trigger other devices; as a COMPARATOR you will have other devices wired directly into its keyboard so that their OUTPUTS manipulate the LED matrix's keys and thus the letters on its screen – this in turn alters the LED MATRIX OUTPUT and becomes particularly interesting when the devices at the OUTPUT are also in some way connected (perhaps via other devices) back into the INPUT.

INPUT

relay (digital) – unless the keys are directly wired into passive pressure pads, input to the keys must be via relay so as not to disrupt the internal electrical circuit

OUTPUT

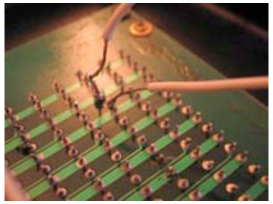
light patterns (digital) – LEDs form letters and graphics on the screen
electricity (digital) – a positive voltage across the wires leading from the LED screen output

PROCEDURE

1. Carefully unscrew the back of the unit and pull apart the two halves. There will be wires leading from one side (where the battery slot is) to the other so ensure that these do not get broken. You will see the back of the LED screen which holds dozens of rows and columns of LEDs. These are the points that you want to solder on to when using the LED output to trigger something else.

2. Select one of the LEDs to be soldered to – how you do this is up to you. You may decide to wire up a set of contacts in the shape of a letter "A" so that every time that letter passes this point it triggers a particular set of devices. You may decide instead to connect up a line of LEDs so that they are triggered successively (if the line is horizontal) or simultaneously (if the line is vertical) as a letter passes across it. Be particularly aware, however, that the analog electronics of the device are intricately affected by wiring other things into them. This means that, though you get a letter "A" travelling across the screen when nothing is attached, as soon as your device is connected, you might see a very deformed "A" travelling across the screen. You can take advantage of this seemingly chaotic (but ultimately repeatable and therefore predictable) behaviour to create much more complex output.

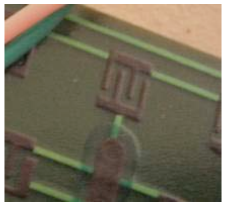
3. The LED output has a positive point and a negative point. If you are triggering a RELAY (which you should do) then it does not matter which way round you connect it. You can check that it is working by wiring it straight into a RELAY and another LED.



4. Having connected one or several devices to the output screen you can now use the input keyboard as normal to program in messages. Notice how the sequence of response changes depending on the message being sent to the screen – you will need to be quite clever in deciding on the connections and the letters that you want to use (see 2 for more on this decision process). Notice, also, how the message gets garbled if you have more connections.

5. A more complex method of entering information into the LED MATRIX is achieved by wiring the outputs of other devices (via RELAY of course) directly into the LED MATRIX keyboard. In this way, the messages on the screen (and therefore the actions of the devices that it triggers) are altered in realtime by the actions of the devices that are connected to the keyboard input. With careful planning you should be able to develop a system in which the outputs modify the inputs in a second-order manner, as explained in the introduction, resulting in complex and intriguing behaviour.

6. First you need to locate the keyboard. This is usually a floppy rubber membrane loosely placed on top of the green soldered electronics board. When keys are depressed, they close contacts across two wires on the board that are interlaced but not touching. You will need to select your input key as carefully as you selected your output LED, bearing in mind the way that you want to control the output. The rubber keyboard membrane may be removed; however you will need it to remember which key corresponds to which letter.



6. You will not be able to solder these wires, but they are exposed and conductive so that they need no other preparation. Take the two wires from the relay output and place them on top of each of the two contacts – make sure that each wire only touches one of the contacts. Then, place

something soft (we have used a piece of wiring casing left over from stripping a wire) across the contacts to act as a spring to depress them against the board and maintain good contact. Tape the whole thing down with good cellotape. You can now trigger letters from another mechanism, which will in turn trigger other devices!

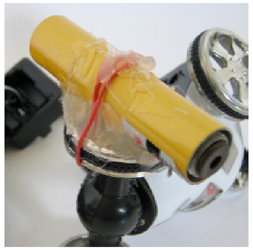
LASER POINTER

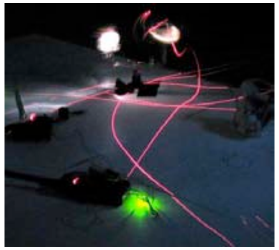
DESCRIPTION
Can create bright light sources on objects at great distance. Alternatively, may be strapped to moving or rotating devices to create lines and patterns.

METHOD
With care, a cheap laser pointer may be dismantled into its constituent parts. However, it is usually easiest to keep it in tact and simply interface it, via a RELAY, through its on-off button. May be combined with RC CAR or FOG MACHINE for linear-type effects.

INPUT
electricity (digital) – 4.5v, intact usually requires 3 x 1.5v pen batteries

OUTPUT
laser light (digital) – shines as a point or, when moving, as a line





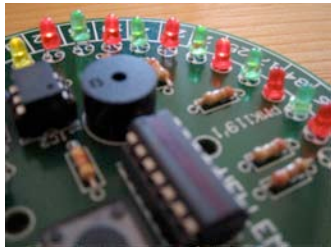
ROULETTE WHEEL

DESCRIPTION
Provides pseudo-random digital output – useful in controlling other devices.

METHOD
Either use LED output signal to power other devices or interface via RELAY. Also requires an input signal (also via RELAY) to trigger the rotation sequence.

INPUT
electricity (digital) – DC, 4.5v.
button press (digital) – starts sequence.

OUTPUT
LED (digital) – sequence of LED outputs, remaining after several seconds on a single output.



MP3 PLAYER

DESCRIPTION
Pre-recorded audio may be played back on trigger.

METHOD
MP3 audio files are placed on the device. A trigger via RELAY is used to start, stop or select tracks that are output either via headphone or loudspeaker.

INPUT
electricity (digital) – DC, 1.5v.
button press (digital) – starts, pauses or selects tracks.

OUTPUT
Audio (analog) – also requires headphones or loudspeaker.

WATER POWERED DIGITAL CLOCK

DESCRIPTION
Creates electricity from water – no batteries required.

METHOD
Use in place of battery, where low-power consumption is required.

INPUT
water (analog) – droplets applied to receptacle.

OUTPUT
electricity (analog) – approx 50mV.

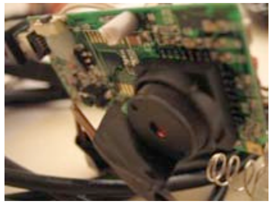
USB CAMERA

DESCRIPTION
Inexpensive USB camera (now available for <£10), may be used to photograph people or objects as part of the designed interaction.

METHOD
Interface the shutter button with RELAY; photos are accessed later via USB download.

INPUT
button press (digital) – shutter button.

OUTPUT
photographs (digital) – low-quality, high-atmosphere 320x240pixel photos.



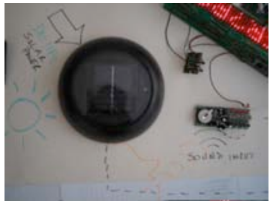
SOLAR POWERED GARDEN LIGHT

DESCRIPTION
Acts both as a power source and as a "sunlight detector".

METHOD
Interface other devices via the LED light output and a RELAY.

INPUT
sunlight (analog) – shutter button.

OUTPUT
electricity (digital) – approximately 3v.



FOG MACHINE

DESCRIPTION
Useful to create "atmosphere" or to provide a screen to catch light-based output.

METHOD
Use in conjunction with projection devices or LASER POINTER.

INPUT
electricity (digital) – mains level with DC converter. Switches on and off thru water-level in receptacle.

OUTPUT
fog (analog) – spills over the edges of receptacle (also splashes)

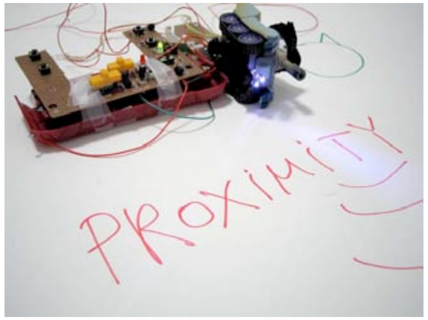
IR GUN, SENSING PROXIMITY

DESCRIPTION
Sensing proximity is a very useful method to sense people passing by, or moving of objects, like opening of doors. Since proximity sensing requires not contact, it does not break down from mechanical wear. Typical commercial proximity sensors produce ultrasound signals, and listen to the echo reflected from any object in its path, very much like bats “see”. Although these usually return some measure of the distance of the object discovered, calculated from the delay of the echo, in most applications people use them to simple be aware if there is an object or not. Here we describe a low tech solution replacing this functionality.

METHOD
Reflecting Infrared
A simple method for sensing proximity is the use of infrared transmitters and receivers, simply using the proximity of any object to reflect the infrared beam. Infrared is like any light, it “shines” on objects, and it bounces around as well.

There is a kind of toy available today, with many different forms and behaviors, that uses infrared light to shoot, control, to transmit data from one object to another, typically a gun to a target, or a remote controller to a vehicle.

Luckily for us, this technology requires pointing the infrared transmitter to the infrared receiver, meaning that if they are pointed parallel, they do not see each other. This is where proximity sensing comes in: using a beam of infrared light from the transmitter, we can use any object to reflect back the transmitted beam, so it gets picked up by the receiver which is next to the transmitter, and ignites the default action the toy is designed to carry out.



In this example of a finished proximity sensor, on the right we can see the field of the infrared light exposed by color manipulation. Although this light is not visible to the human eye, through simple digital cameras, like phone cameras, we can usually see it as a "blue" light (useful for debugging).

INPUT
Proximity of opaque objects, could be people passing by, things moving, possibly even rain

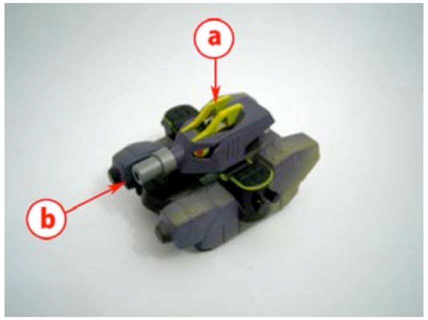
OUTPUT
Vibration, motion, LED

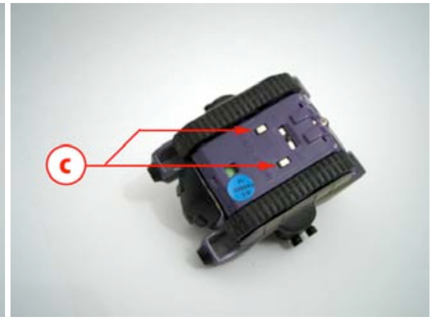
PROCEDURE

In this example we will use a small remote controlled toy, which also has an infrared gun, to aim and shoot at its counterpart.

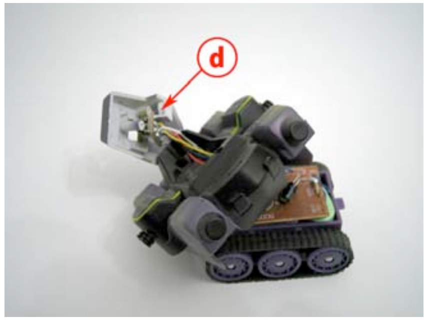
What we need to do:
- Open all cases, to expose the IR diodes on the car and the remote
- Align the cars and the remote's IR diode that they point in the same direction
- Find a way to press and hold a button on the remote
- Find an action to trigger using the toy's output

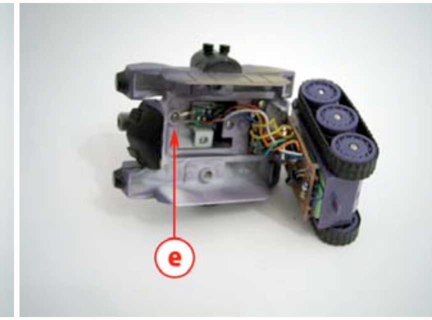
The car



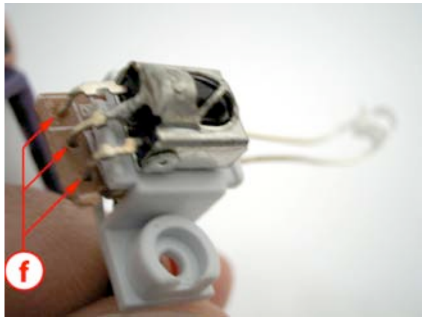


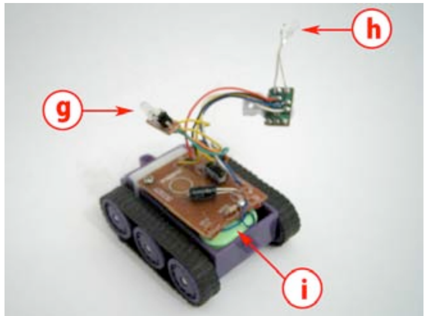
01 find the infrared diodes
First let's find the infrared diodes. Look for small LED looking parts, they are the infrared transmitters or receivers (or both), a and b on the image above. These are sometimes covered with shiny black plastic. On the right, c shows the power connectors, that can be used to eliminate the need for recharging the car.





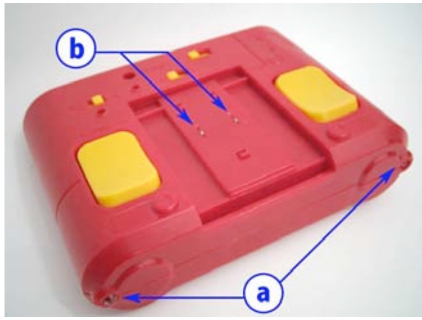
02 open the case
Carefully open up the plastic case – you might need to use a cutter or grabbers, since these toys are usually glued. Take care that the soldering of the cables connecting the IR diodes doesn't break. d and e show the location of the diodes in our case.

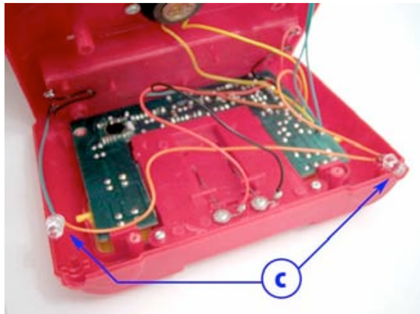




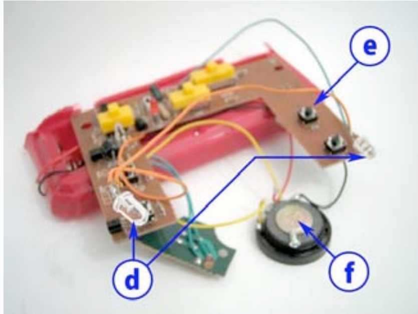
03 free the diodes
IR receivers, shown f above, have 3 legs whereas normal LEDs have 2 legs; this is an easy way to identify them. Here also we can see how this diode is covered with the shiny black plastic, which is actually a filter for infrared light, filtering out everything else. After removing this, you have two objects, g(receiver) and h(transmitter) hanging on wires. The battery in this toy is marked with i.

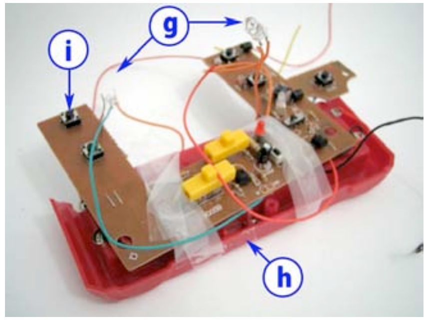
The remote



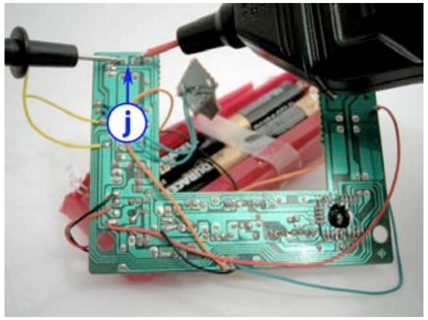


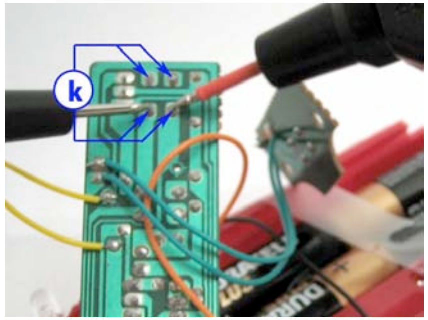
04 find the infrared diodes
As above, first find the diodes, marked with a here. The power connectors to the car are marked with b. Open the case, here it is much easier to set the c diodes free.



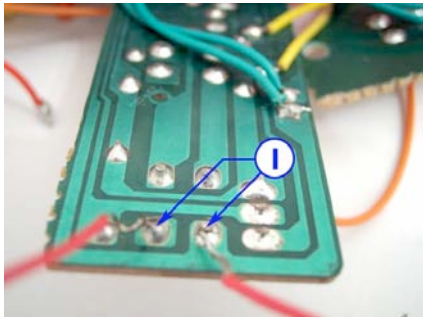


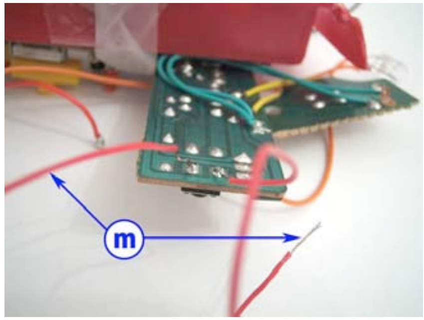
05 remove the case
Next you need to get rid of the bulky casing, to have access to internal parts. The part we usually keep is the battery compartment, which is very useful to keep batteries connected and together. Simply break off the part that holds the batteries (you can also h tape it together). Now, exposed we have d or g for the two diodes, f is a speaker, that you can simply cut away if you don't want the noise, and an important element, e or i is the little button, that is pressed if we want to move the car. Now turn around this printed circuit.





06 find the action button
Just on the other side from where the button was, you can find several soldering points j, connected to the backside of the button. If you are more lucky than us, you can see only 2 such connections, meaning that if you close those, connect them with a wire, you have the button pressed. In our case, we have four connections as k shows. Now either with the less safe (for the toy) trial and error method, you can try to connect any two, or if you see action, (the car must be in the remote's sight) you have found the right points. We used a slightly more sophisticated method by measuring resistance with a meter, which should drop to zero if the button is pressed. We found that the top two should be connected.





07 connect the action button
On the left, shown with i are the two points you should connect – using soldering is by far the best option here. Once you have two cables soldered, you should simply connect them m together.

See BODY TRIGGERED LASER for more information on how to use these two together for proximity sensing.

RC CAR – WIRELESS LINK

DESCRIPTION

Radio controlled toy cars have been around for a while, but in recent years a very low cost, tiny version has emerged, that usually has a larger remote control with batteries, and a small controlled vehicle that needs to be charged from the remote. Due to its cost and simple construction, this toy is ideal for wireless networking. By RC CAR we really mean any radio controlled little thing, not specifically cars, as you'll see in our example.

Although one would think of RC CARS as great devices to carry things, in these examples we focus on the interaction and space related possibilities, so the features easy to hack into in this aspect are

-1 way radio connection, with 9 options for the message
-engine that can vibrate, rotate, pull wires

METHOD

To create a wireless connection with an RC CAR, on one end we need to hack into the controller, to send the signal interfaced to the event we want to transmit, and interface the cars actions on the other side. A simple method is to listen to the vibration the motor creates, for example with a CAT; the more advanced option is to connect several RELAYS to parts of the car, hence allowing more complex messages to be sent.

INPUT

Electricity – 3-6 Volts
Button press – 4 options digital, with 2 combined reaching 9 options
Combinations of move-turn: 0-0, 0-1, 0-2, 1-0, 1-1, 1-2, 2-0, 2-1, 2-2

OUTPUT

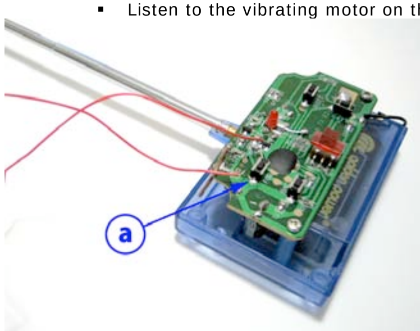
Radio signals
DC Motor movement, direction
servo motor position
Usually LEDs

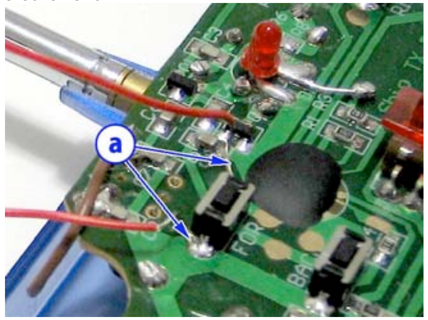
PROCEDURE

In this example we will use a small remote controlled submarine and its controller.

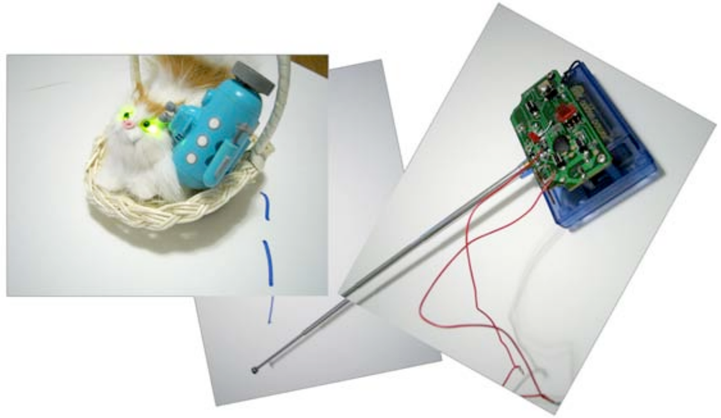
What we need to do:

- Open the remote's case, and connect to one of the buttons.
- Listen to the vibrating motor on the other end





01 Connect to the remote
Open the case of the remote controller, and find the buttons that are pressed to do an action, like forward / back. These are usually smaller than the buttons you press on the cover, but still can be pressed, and they should work just as well without the cover. The buttons usually have two to four connections, 2 in our case a. You can find the right ones by connecting them directly with a small wire. Once you have found the right ones, solder them to the OUTPUT of a RELAY. The input to the relay depends on what you are using to trigger the wireless action.



02 Listen to the vibrating motor
On the other end of the link simply listen to the vibration of the motor. You can do this easily with a CAT. We mentioned above that you can also use a more advanced method, by listening to combinations of move-turn-direction. This gives a number of options, 'messages' you can send, but which you need to resolve on both ends. Using a set of RELAYS, you can trigger both forward motion and left turning for example, while on the remote side, you need to listen to the actions with RELAYS as well, and build logical gates like AND gate create combination triggers.

ABOUT THE AUTHORS

Usman Haque has created responsive environments, interactive installations, digital interface devices and choreographed performances. His skills include the design of both physical spaces and the software and systems that bring them to life. He has been an invited researcher at the Interaction Design Institute Ivrea, Italy, artist-in-residence at the International Academy of Media Arts and Sciences, Japan and has also worked in USA, UK and Malaysia. As well as directing the work of Haque Design + Research he is currently teaching in the Interactive Architecture Workshop at the Bartlett School of Architecture, London.

He is a recipient of a Wellcome Trust Sciart Award, a grant from the Daniel Langlois Foundation for Art, Science and Technology, the Swiss Creation Prize, Belluard Bollwerk International and the Japan Media Arts Festival Excellence prize. His work has been exhibited at the Institute of Contemporary Arts (London), Ars Electronica, Transmediale, Hillside Gallery (Tokyo), The National Maritime Museum Greenwich and the Tokyo Metropolitan Museum of Photography. His work has also been presented at international conferences including Siggraph, VSMM (International Society on Virtual Systems and Multimedia) and Doors of Perception.

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Adam Somlai-Fischer (Szabolcs, 1976 Budapest), an architect and interaction researcher, founding partner of Aether Architecture, an adventurous practice working on interactive architectural projects. Aether's work has been recently exhibited both at ISEA 2004 in Helsinki and at the Venice Biennale of Architecture, and published in various design magazines.

Graduated from the Architecture + Urban Research Laboratory, KTH, Stockholm, Adam has been teaching at the Architecture and Media technology departments at KTH, working as a guest researcher at the Smart Studio, Interactive Institute in Stockholm, and currently collaborating with the Media Research Center at the Department of Sociology and Communications, BUTE, Budapest. His thesis, Mediated Spaces, looking into how new technologies of connectivity have altered architecture, has received international publicity.

www.aether.hu