Fed up with all that feedback as your guitarist goes near the speaker? Would you twiddle with the knobs, or would you write some audio software to balance the speakers automatically for you? Do you still manually create playlists for your iPod? The audio engineers got fed up of doing that too so they’ve been coming up with ways your computer can do it for you, whether by analysing your music or working out your moods. Don’t accept that music has to be made and played the way it’s done now. Invent a new way. Read on.

If you are excited about music and want to combine it with a love of science and engineering, then Audio Systems Engineering may be the subject for you. We think the best way to work out what a subject might be like at university is to see some of the leading edge things the specialists get up to. After all, tomorrow’s jobs are based on today’s research. In three years time that is the kind of thing you might be capable of creating too. Of course by then the technology will have moved on. That’s fine as you will be at the leading edge of the music technology revolution.

**Mad about Music Technology**

Most people love some kind of music. Some even dream of being rock stars, but there is an exciting new way to mix music into your future. When Electronic Engineering, Physics and Computer Science meets musical skill, out of the mix comes exciting innovations that are changing the way we enjoy our music. It’s all thanks to audio systems engineers.

**Audio! Action**

THX is a standard for cinemas to ensure a movie looks and sounds exactly the same no matter where it is played. The guidelines were developed at Lucasfilm and named after THX 1138, George Lucas’ first feature film. To be able to display the THX logo a cinema needs to pass inspection from Lucasfilm’s THX division.
These new augmented instruments, such as a guitar processed by a laptop, have no boundaries to the sounds that can be made, and that means there is a whole new musical landscape for creative electronic musicians like Atau Tanaka of Newcastle and Jean-Baptiste Thiebaut at Queen Mary to explore. The way it works is that you extract digital information from the instrument you are playing and map it to a virtual space where each point corresponds to a digital sound. The sound that is heard depends on both how you place the sounds in that virtual space and how you play the instrument.

In a traditional live performance using electronic music, the performer just programs a computer with the music to play in advance and then more or less lets it get on with it during the actual show. Augmented instruments bring back true performance – the artists need to develop a new virtuosity with their instruments. They have to play live again.

His movement becomes the music

So what about cyborg music? Well, Atau Tanaka’s instrument is the ‘Biomuse’. What’s that? Well, basically it’s himself. He is wired up with electrodes that detect the electrical signals that naturally travel around his body as his brain controls his movements. Those signals are captured by the Biomuse and mapped to the virtual sound space. His movement and gestures themselves become the music.
Sounds like music

So how is the trick done? Well first we need to look at sound and music. Sound is a change in air pressure, so when Mariah Carey sings her vocal cords change the air pressure and the sound wave passes to our ears. Our eardrum converts this wave of air pressure into a mechanical movement in the tiny bones in our ear. That in turn is changed into a nerve signal that goes to our brain. A microphone works in the same way. The pressure wave moves a part of the microphone called the diaphragm, and it's this movement that turns the sound pressure wave into an electronic signal. When we are recording digital music we take many millions of very rapid samples - measurements - of the electrical signal and turn it into numbers to store.

Frequency asked questions

One of the things that characterises the sound wave is the frequencies it is made of. Frequency measures how quickly patterns repeat. A very dull sound might just be a single frequency. The sound gets louder then softer, say every second, and repeats this cycle every second until you switch it off. This tedious sound would have a frequency of 1 Hertz (1 Hertz means one 'cycle' per second). Normal music doesn't sound at all like this dull repeating noise, but as it happens you can take any sound or music and, using some special mathematics, convert it into a set of different frequencies. Each of these frequencies alone just sound dull but added together it makes the music. The same idea is used in a music synthesiser; you can make the sound of any instrument by adding together the right frequencies. So we now know that our music can be described as frequencies, and we can start to play tricks.

Ear, Ear

Turns out that our ears, though very clever, don't do everything well. Certain frequencies will stop you from hearing other close by frequencies. These special frequencies 'mask' the presence of the others nearby. Once you know this (it was discovered through lots of experiments on hearing), then you know there is no point in using up valuable computer memory storing information on the frequencies your ears can't hear. So you don't store them. Kazam! You remove these frequencies altogether but, because they were masked by the other frequencies you can hear, you don't notice they have vanished.

Believe it or not, your MP3 player is actually playing a sonic magic trick on you. MP3 is a format, a way of storing sounds and music so that they take up as small amount of memory in the computer as possible. That way you can have hundreds of your favourite tracks on your iPod, which is really just a small computer disc that stores the digital music. The trick is to find a way to remove some of the sound information without your ears and brain noticing it. In effect the clever audio engineers who developed MP3 are playing a trick on your ears.

The magic of MP3
Bunny in the headlights
There is another cunning effect you can use. When we see a bright light, for a bit after it we can’t see a dim light. Our eyes change so we aren’t dazzled by the bright flash. But this leaves our ability to see dimmer lights reduced for a bit. Same happens with sounds. A loud sound will stop you hearing a quieter sound that follows just after. So again we can look at the digital music signal and work out all the places where a loud sound is followed by a quiet sound, and then cut the quiet sound out. Saves computer memory, and again the trick is that your ears won’t notice that the quieter sound is missing.

Sonic sleight of hand
What gives MP3 its great ability to compress music? It’s using these tricks to make those parts of the sounds vanish that your ears won’t notice. We need to store less data but the music sounds just as good. To be able to give the world MP3 audio engineers needed to work on ways to do the maths, as well as understand how our ears work. So the next time you listen to your MP3 player just think of all the engineering making up the wonderful din.

Cricket songs
Navigation - finding their way around - is a challenging problem for robots but crickets have inspired researchers at the University of Stirling to come up with a new way for robots to do it. Female crickets can find male crickets by homing in on the song they sing. A cricket’s ears are actually in their front legs. Sounds arrive at the ears, which being on the legs, are as far apart as is possible in a cricket. The legs act as long tubes down which waves of pressure pass as a result of the sound waves hitting them. A sound on one side of the cricket arrives at the ear on that side sooner than the other ear. This turns into a different amount of pressure in the tubes on either side of the cricket’s head. The cricket’s brain can work out locations from the pressure differences, telling the cricket where the sound is coming from.

The Stirling researchers have created a similar mechanism to work in robots allowing them to navigate towards sounds. It uses an artificial brain that works in a similar way to a cricket’s to turn the pressure signals from the sound into the knowledge of where to go. It uses what is known as a neural network - a computer version of the neurons in biological brains.

In a twist on this idea researchers at Swansea and Waikato in New Zealand have developed a system for people to navigate by song. Using their OnTrack system the music on your iPod can direct you by changing aspects of the music. For example, if the volume is louder in your left ear then go left. No longer will being engrossed in the music you love mean you risk losing the one you love!

Audio! Action
Guitarist Les Paul, after whom the famous electric guitar design was named, is an inventor and musician. He is a pioneer of recording innovations we take for granted today including overdubbing, delay, phasing and multitrack recording.
Making music has always been a social thing. People play in bands or orchestras, and even composers often work in pairs like the Beatles’ Lennon and McCartney, Rolling Stones’ Mick Jagger and Keith Richards or Jack and Meg White of the White Stripes.

Up till now playing or composing in groups has tended to need the people concerned to be in the same place at the same time. That used to be the case for people working together as well. The Internet and mobile phones have changed all that though. Networked games allow people to play together without ever meeting. So if we can both work and play together in groups across continents, what about making music? What kind of instruments would allow people to work creatively and compose together, and what kind of music would you get?

Daisyphone, is a new tool that allows you to compose music with your friends, regardless of where they are in the world. It’s developed by Nick Bryan-Kinn’s team at Queen Mary. Its floral dot-to-dot design lets people play loops of music together, continually adapting the loops depending on the sound and on what others do. You can all see and hear what the others taking part do, wherever in the world they are. It is also very visual – you can hear the patterns you doodle, or even what your name sounds like.

Daisyphone was developed as part of a research project at Queen Mary that explores the collaborations of jazz musicians jamming and how their creative intensity can be captured online (see “All that Jazz”, page 7). Daisyphone is freely available for anyone to use (find it on the Audio! website), so give it a go. Learn to play a new group instrument, explore the emerging world of online group creativity and maybe make some new musical friends at the same time.
When doing an improvised performance jazz musicians seem to be able to lock in to what the other band members are doing. They are taking part in a performance but are also composing as they go. After a while they seem to instinctively explore new sounds together. What is going on? How are they communicating? It sometimes seems like they must be psychic!

The secret for musicians being creative together, so that they get high quality results and also have a fun time doing it, is to develop a strong feeling of ‘mutual engagement’. That just means they are deeply involved both with the music being created and with each other. When that happens they start to push back the boundaries of the understanding they share, both of the experience they are having and of their expectations of what will happen next.

Musicians develop this sense of mutual engagement in a session by combining musical signals with spoken and visual cues. Simple things like stepping backwards or forwards slightly at the right time can make a difference. Unlike when people have a conversation, communication in a jamming session is not so much about passing information, it’s about increasing this sense of mutual engagement. Another difference is that these subtle things the musicians do tend to happen together rather than one after the other as in a conversation.

How does film technology help? The way they create computer-generated characters is by using a ‘3D motion-capture’ system. The way this works is that cameras positioned all round an actor modelling the character capture the precise movements of different part of their bodies. That information is then used to control computer-generated characters. If you want to study the subtle ways people behave in groups, like our musicians, the same techniques can be used. All the subtle gestures the people jamming are making can be captured and analysed to see how the intense relationship is happening.

Nick’s aim is not just to understand what is happening in such sessions, of course, but eventually to look at how new computer technology might be developed to support these activities.

Some day soon social networking could take a further leap forward, helping people to have intense jamming sessions, even across continents.

Suppose you are interested in music and also have the kind of technology used to make computer-generated creatures in films like Lord of the Rings’ Golem. What could you do? Nick Bryan Kinns’ team at Queen Mary have been exploring how musicians have such an intense time when they are jamming.

All that Jazz
Getting the right mix

During a performance, the sounds from the instruments and the sounds picked up by the microphones are routed to a mixer and adjusted. Sounds come in different frequencies, which is what determines whether musical notes are high or low. What sound engineers do is to adjust the volume of the different frequencies to get the best mix. After mixing, the sound is then sent back to amplifiers and speakers, but this sound can also be picked up by the microphones. The system is in a loop, and if at any frequency it is louder than the original sound picked up by the microphone, then feedback will occur. The engineer needs to continuously check whether any frequencies are too loud and adjust them. Sounds come in different frequencies, and so the sound engineer needs to be able to monitor all frequencies simultaneously. The engineer needs to listen carefully to the mix and be able to adjust the volume of each frequency to prevent feedback.

Before a live show there is usually a sound check, where the sound engineer adjusts the sound. During a performance, the sound from the instruments is routed to the mixer and adjusted. Sounds come in different frequencies, and the engineer needs to be able to monitor all frequencies simultaneously. The engineer needs to listen carefully to the mix and be able to adjust the volume of each frequency to prevent feedback.

Guitar heroes: fixing feedback with software

Feedback can cause an audience to cover their ears, and musicians to walk off stage in frustration, but it has also allowed some guitarists to create intense musical experiences. Jimi Hendrix harnessed it to great effect, but squealing feedback is not something you normally want at a gig. The trouble is, getting rid of it can affect the quality of the music. But now labour-saving software for sound engineering promises to make acoustic feedback a thing of the past. Researchers at Queen Mary have created a device that automatically prevents feedback in live performance, and allows bands who can't afford sound engineers to give feedback-free performances.

Researchers at Queen Mary have created a device that automatically prevents feedback in live performance, and allows bands who can't afford sound engineers to give feedback-free performances. So far, the device has been tested in a lab and in some small venues. The device works by using microphones to monitor the sound, and then using software to adjust the volume of each frequency to prevent feedback. The device has been tested in a lab and in some small venues, and it has been shown to be effective in preventing feedback.

Feedback can cause an audience to cover their ears, and musicians to walk off stage in frustration, but it has also allowed some guitarists to create intense musical experiences. Jimi Hendrix harnessed it to great effect, but squealing feedback is not something you normally want at a gig. The trouble is, getting rid of it can affect the quality of the music. But now labour-saving software for sound engineering promises to make acoustic feedback a thing of the past.

Researchers at Queen Mary have created a device that automatically prevents feedback in live performance, and allows bands who can't afford sound engineers to give feedback-free performances.
Software for the sound guy

This is where the new software comes in. Joshua Reiss and Enrique Perez of the Centre for Digital Music at Queen Mary have created software that prevents feedback from occurring and frees the sound engineer to focus on music quality. Given the preferred setting the engineer found in the sound check, the software automatically monitors all the changes in the mix made by the sound engineer. It uses a sophisticated mathematical technique to determine if any of these changes would produce feedback. If so, the system will simultaneously reduce the volume just a bit. This prevents feedback without noticeably affecting the mix, yet still allows the engineer to make the required change.

This is quite different from what sound engineers normally do to fix feedback, which is really more a treatment for feedback rather than a prevention. They usually identify when feedback has occurred and attempt to remove it by changing the mix of frequencies in the signal. Though this can be quite effective for speech, it’s problematic for music since messing with frequencies changes the sound of the music. Also, because sound engineers usually only treat the feedback once it has begun to occur, it can be difficult for them to correct things at the right time. They might remove some sounds that the band want the audience to hear (like if a super-vigilant sound engineer removed all of Hendrix’s feedback), or they might allow some unintentional feedback to slip through.

Testing, testing

Josh and Enrique tested their software with the help of a visiting student who just happened to have brought his guitar. The student strummed into a microphone, which sent the sound to a mixer where Enrique played with the settings. The resulting signal was then sent to a speaker. When their software ran on the mixer, there was no feedback, but when the team switched the software off, they got the characteristic squeals.

Josh and Enrique’s work is part of a larger project on automatic mixing for live sound. The goal is to create a set of tools that automate as much of the routine tasks performed by a sound engineer as possible, to set them free to do more interesting stuff. For instance, one part of the project allows each musician to hear a customised mix where their own instrument is enhanced above the rest of the music. Another aspect automatically determines the preferred placement of the instruments in a stereo mix so that each sound is clearly distinguished.

The automatic mixing research could allow an engineer to concentrate on the more interesting aspects of live mixing, or allow a small band to perform without the need of an experienced sound engineer. In both cases, it could lead to better quality live performances, and fewer headaches for gig-goers.

Audio! Action

A Star is Born was the first film to be shown using Dolby surround sound. Electronic engineer Ray Dolby invented the audio processing method to reduce the ‘background hiss’ previously present in sound recordings.
Music is data

To a computer, music is just data - a file in a particular format like MP3 – it's all just 1s and 0s. How do you know what a particular MP3 file contains? MP3 is just sound data. Unlike a CD, a computer file doesn't have a label stuck on it to conveniently tell you what is on it. More to the point, how does my iPod know what track each file is to tell me on the screen? The computer equivalent of a sticky label is called 'metadata'. Metadata is more than just a substitute for a sticky label though. It is the thing that is driving the world-wide-web of the future - the semantic web. A new web, not just of words, but of meaning.

The idea of metadata is simple - it's just data about data. What does that mean for your music collection? Well the actual data is the music: the sounds that Leona Lewis, 50 Cent or Kylie Minogue actually record. That is what you are really interested in but it isn't much use without metadata to tell you what you have. The metadata is any data about the file, it tells you what it is - the name of the artist - Nickelback maybe, the name of the song - 'If Everyone Cared', the album it's from - 'All the Right Reasons', and so on. Metadata can be more than just the kind of information on an album cover though. It can also be information about the sound too.

What makes metadata powerful though is that it comes with meaning. You don't just know 'All the Right Reasons' is connected to the track, the metadata tells you that it's the album title, and not say the name of the group.

The problem with my music collection is there is too much of it. I have hundreds of albums, thousands of tracks, all conveniently stored on my iPod. Trouble is I struggle to remember what I have that might fit my current mood. I end up just playing a few over and over. If only my computer could act like a DJ and, from its extensive knowledge of music and my collection, choose a playlist to suit - or even suggest new tracks I might like to buy. Turns out thanks to recent digital music research, and a new way to turn your music collection into a set of numbers, it probably can!
But what do you mean?

Attaching meaning to data is what the semantic web is all about. At the moment search engines work without understanding. You give them some words and they search for web pages containing those words. That is why if you search for Queen you don’t just get results about the rock band you were thinking of but also about the British Royal Family, films about monarchs, and even a university. The problem is the search engine doesn’t know what you mean, or what the words in the pages it has found mean either. It just knows the same words appear.

Metadata changes that. By giving meaning to the words, meaning to the music files, it allows powerful new tools to be built. Computers can start to behave much more intelligently. That is the aim of Mark Levy, Chris Sutton and Mark Sandler, Electronic Engineers at Queen Mary, University of London. As part of the research of the Centre for Digital Music, they have developed a system called SoundBite. It makes use of metadata to turn your computer into an intelligent personal DJ with a love of your music collection. >>continues on page 12
Getting to know you

The first thing SoundBite does is to get to know your collection by going through every track. Rather than listening to them though, it analyses them looking for features like how repetitive it is. It then pulls out a set of 40 numbers that describe different features of the music. These numbers can then be used to compare it to other tracks. Each gives some distinct meaning to the sound - similar sets of numbers imply similar tracks or tracks for similar moods.

Once SoundBite has come up with the numbers for every track, it is ready to create playlists. It now knows your music collection better than you do. As a result it knows you too! Choose a single track you can think of that does suit your mood - perhaps one you listen to all the time - and SoundBite will create a whole playlist of tracks to fit, probably including ones you’d forgotten you had.

SoundBite isn’t a finished product. Rather it is a part of an ongoing research project exploring new ways such a “computer DJ” could work. You can download it though if you wish (it’s free) and in doing so not only get your own personal DJ but also help the researchers at Queen Mary investigating what the iPods of the future could be like.

For example, one possibility is for SoundBite to act as a recommender service. Rather than just constructing playlists from your own collection, the system could find similar tracks from the whole range of its user community’s music. It doesn’t just know about your music after all. That means it can suggest tracks to buy you’d like that you’ve never heard before. This could be based on your whole existing collection or just a single current favourite. I just discovered Fictionplane by stumbling on the song “If only”. Perhaps SoundBite could have noticed I liked that kind of music and recommended it to me ages ago rather than leaving it to chance. Are there other groups playing similar music that I don’t know about yet? A future version of SoundBite might tell me that too.

How might SoundBite do all this? - by collecting as much information as possible, with meaning, about each track. The similarity information is one source, another is from the Web services that record information like track names and allow me to copy a CD onto my iPod with all the track information. It can also use the annotations that you and I add to our collections for our own use, as well as information like the combinations of tracks people listen to a lot that your iPod works out for itself. There are lots of ways the available information might be used. The question is not only which ways exist, but which ways work best. Out of all that information which combination leads most consistently to recommendations I agree with? How well do the playlists rate when compared with the tracks a human would actually rate as similar? Are there important features of similarity still missing? There is lots of research still to be done.

The beauty of the SoundBite approach though is that it doesn’t need human reviewers. Also as soon as anyone registered discovers a new band they love, it automatically becomes available for recommendation to others. Better still it is all ultimately based on actual similarity of the sound and what really is being listened to, not just personal prejudices or media-fuelled hype.

So signup to SoundBite at www.isophonics.net Enjoy your music collection to its full, and personally help create the future where computers really do have an ear for music.

Freedom from the Click

These days, drummers are mere slaves to recordings. When a band uses a pre-recorded audio loop at a gig, the drummer wears headphones. Why? Because they’re playing along to a “click track”? It’s just a recording of clicks in sync with the audio loop so the drummer can keep time. Why should the drummer be the prisoner though? Andrew Robertson, a PhD student at Queen Mary, aims to change all that and make the loop keep time with the drummer instead!

His “B-Keeper” system listens to the drumbeats. It then adjusts the tempo of a music sequencer as it plays so that the looped music keeps in time with the drummer. If the drummer speeds up, the music speeds up too! That brings back a real “live” feel, making the drummer properly part of the performance again.

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See B-Keeper in action at uk.youtube.com/user/BKeeperSystem

Maths Makes Music

Download free mathematical ringtones from www.audio4fn.org
Listen to your spreadsheet

Do you listen to your computer as often as you should? Most of the beeps made by PCs quickly become irritating. Using sound to make computers easier to use doesn’t have to be that way though.

Using sound to present data is called ‘Sonification’, and it has some notable uses we wouldn’t want to be without. From heart monitors in hospitals to the sounds produced for Radar operators, sonification of data has saved many lives.

In the right situation, sonification can make patterns in data much more obvious. This is the idea that Tony Stockman from Queen Mary’s Interaction, Media and Communication group is investigating. Tony’s team is developing usable sonification systems for visualising large amounts of data and his student Greg Hind built a working prototype system to sonify spreadsheets as his MSc project work.

Screen readers already exist to help blind users. They just read out whatever words are under the cursor. This means a blind person can examine a spreadsheet a cell at a time, it’s helpful, but it’s hard to get the big picture that way. The Queen Mary system gives you a second ‘sonification cursor’. It can be used to travel quickly over rows or columns, making different sounds depending on the data it passes over, independently of the normal cursor.

When a cell value is really low or high, for example, the difference in sound stands out. The two cursors can be easily snapped back together, which means you can quickly get the actual value of an interesting cell you’ve found.

Once you have this basic system there are lots of add-ons you can start to think about. For example, why not add an ability to bookmark particular cells, attach sounds to particular text strings (not just numbers), or automatically sonify areas of the spreadsheet rather than it being done by hand. All these features have already been added to the system and there is lots more that can be done.

So next time you are staring at rows of dull figures, why not listen things up and listen to your data instead.

Sensory Theatre

Martin Ware, record producer and founder of 80s pop groups The Human League and Heaven 17, has worked with the likes of Tina Turner and Chaka Khan. He is currently a Visiting Professional Fellow with the Centre for Digital Music at Queen Mary. In his current ‘Threeways SEN School’ project, he is using his creative audio engineering skills to create a “sensory theatre”, a totally innovative learning environment for disabled children, immersing them in a multi-sensory experience.
In regular beatboxing, performers try and fake the sounds of drumbeats, synthesizers and DJ-ing using only their voice and a microphone. Dan’s been beatboxing for about seven years, but the extra weird sounds in his performance are from something new: he’s found a way to hook the sound card from a retro computer up to his microphone. His voice gets translated through the system so whatever sound he makes, from a clunk to a hiss to a chk-chk-chk, it comes out in the voice of the biggest home computing star of 1985, the ZX Spectrum.

Express yourself

Why do this? Because every day we humans use one of the most expressive instruments on the planet – our voice. Dan wants to capture that expressiveness and use it to control musical instruments too. “If I want to make music,” he says, “surely I should just be able to say ‘it goes like this – blah blah brah rah rah’ rather than having to learn how to play a MIDI keyboard or anything like that.”

If you’ve ever taken music lessons, you’ll know that you spend most of the time in the beginning just learning how to get the notes right. You have to know your own instrument pretty well before you can start adding expressiveness and mood into the mix. Part of the reason for that is that there aren’t many ways to change the sounds you make. When Dan uses a keyboard as an example. Even on an expensive keyboard you can only really change the notes you play, how fast you play them, and how loudly. “So if you want to make sad music you have to know how to do it on that specific instrument. But everyone knows how to make mood with their voice – we do it every day. And a voice can communicate so much all at once. There’s lots of information.”

At first it sounds like a primitive PlayStation making babtalk. There’s a jumble of electronic bleeps and fuzzes coming out of the speakers, but with a kind of human sound too, like gargling and cooing. Soon the strange noises take on a rhythm, and it’s like a combination of a drum machine, someone’s voice and the soundtrack from the original Super Mario Bros. That may be hard to imagine, but there’s a good reason. When Dan Stowell, a PhD student at Queen Mary, beatboxes, it’s a sound you’ve never really heard before.
Maths and maps

The actual business of turning Dan’s beatboxing into computerised bleeps depends, in part, on some good maths. For every moment of his performance, a computer analyses the sound of his voice. “You just get a load of numbers out,” says Dan. A sound wave contains lots of information, so when he was designing the system, one of the toughest bits was deciding which information to keep and use. What’s more, the sort of information Dan really wanted is the kind of stuff that humans can pick out of a sound pretty easily, but computers find difficult. “Is it growly, is it whispery, is it strained? Is it sad, is it happy? Those sorts of things are still really quite slippery.”

What he had to do was shave off lots of the numbers until he was left with only the best ways of measuring all those hard-to-define qualities of a sound. While he’s beatboxing, the computer tracks and measures just those qualities and spits out numbers for them. That still leaves the problem of translating those numbers into ZX Spectrum noises. And to solve it, Dan made a map.

Dan’s map was of the different sounds the Spectrum sound card could make. A really loud, hissy noise would be at one side, for example, and a really soft, pure tone would be at the opposite end. You can divide up any map into precise spaces by giving them co-ordinates – numbers that tell you what position you’re in. So once he’d made the map of Spectrum sounds, he gave them all numbers that would correspond to the ones his computer sends out during his performance, while it’s tracking his voice. As Dan explains, it’s “just like you might take two printed maps and put them on top of the other and say, ‘if I’m here in my voice map I should be here in the synthesiser map’. With Dan makes a really noisy sound with his voice, the computer looks up the equivalent noisy sound on the ZX Spectrum sound map and plays it. What’s more, because no one ever programmed the Spectrum to make such strange, voice-like noises back in the ‘80s, Dan says, “pretty much everything I do as a sound that the ZX Spectrum never made before”.

Follow the sound of my voice

Since teaching computers to analyse the human voice is something new in electronics research, Dan’s work will eventually lead to a PhD from Queen Mary. Even so, his beatbox synthesiser has always been designed to be used in real world performances. And he wants to get to the point where it’s not just one synth he’s controlling. He’s looking forward to performing with a whole bank of synthesizers, all tuned to the sound of his voice. One day you might even be able to play an instrument without really knowing how – all you’d have to do is sing a line and it would come out of the speakers sounding like a keyboard, a cello or whatever instrument you wanted. Which means that in the future, any good singer (or beatboxer) could have a whole band (or even an orchestra) at their disposal.
Programming punks

It’s a tough task to get a robot to learn what punk music sounds like, but there are lots of hints lurking in our own brains. Inside your brain are billions of connected cells called neurons that can send messages to one another. When and where the messages get sent depends on how strong each connection is, and we forge new connections whenever we learn something.

What the robots’ programmers did was wire up a network of computerised connections like the ones in a real brain. Then they let the robots sample lots of music: Fiddian’s collection of classic punk. That way the connections in the neural network got stronger and stronger – the more music the robots listened to, the easier it got for them to recognise what great stuff it was. When they recognised a style, they would dance, firing a cylinder of compressed air to make them jump up and down.

The robots’ first gig

The last step was to tell the robots to go out and enjoy some punk. Whenever a band begins to play, the robot’s computer system analyses the sound coming from the stage. If the patterns in it look the same as the idea of punk music they’ve learned, the robots begin to dance. If the pattern isn’t quite right, they stand still. For lots of songs they hardly dance at all, but which might seem weird since all the bands that are playing the gig call themselves punk bands. Except there are many different styles of punk music, and the robots have been brought up listening to Fiddian’s favourites. The other styles aren’t close enough to the robots’ idea of punk – they’ve developed taste, and it’s the same as Fiddian’s. Which is why the robots go crazy for Neurotic and the PVCs. Fiddian’s songs are influenced by classic punk like the Clash, the Sex Pistols and Siouxsie & the Banshees, which is exactly the music he’s taught the robots to love.

As the robots jump wildly up and down, it’s clear that Neurotic and the PVCs now have three tall, tough, computerised super-fans.

If you are mad about music technology, then visit www.audio4fn.org for more on the fun side of Audio Engineering.