RTT TECHNOLOGY TOPIC
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Sight, Sound and Cellular - Signature Value

Introducing this month's Technology Topic

In last month's Technology Topic, 'Mobile Metadata', we discussed how 'information about information' adds value across the five 'value domains' of cellular radio - radio system, audio, positioning, imaging and data value.

We introduced the concept of signatures including audio and image signatures.

This month we explore the role of signatures in more detail, looking at how signatures have been used historically, how they are used today, how they will be used in the future

Super Phones and Signature Value

In previous Technology Topics we have introduced the concept of Super Phones. Standard phones help us to communicate with each other, smart phones help us to organise our business and social lives, Super Phones help us to respond and relate to the physical world around us. Super Phones use 'extended capture' capabilities to help us to interpret and record our surroundings. A simple example is a camera phone with extended audio recording capability and wide area and local area positioning functionality.

To be useful, Super Phones have to be able to recognise the signals that they can see or hear. Signals have certain properties that make them recognisable - the 'signature' of the signal.

As humans, we use our eyes and ears to detect threat and opportunity. Particular threats have specific visible and audible signatures; particular opportunities have specific visible and audible signatures. We recognise these signatures, place them within a temporal, spatial and social context and use that information to make responsive decisions.

It may be ambitious to expect a cellular phone to develop an advanced sense of social awareness. It is however, perfectly possible for a phone to hear things and see things that we cannot see or hear and to provide us with additional information on our physical surroundings that can be directly beneficial.

We can choose to design phones that can hear audio frequencies below or above our audible hearing range; we can design phones that can 'see' objects that are invisible to the naked eye.

A Super Phone can exploit these functions to provide extended 'signature recognition

capability'.

The ability to recognise signatures, defined as we shall see very broadly, makes a phone more useful

What is a signature?
A signature is a sign that allows us to identify the nature of a particular person or object.

The presence of a signature provides us with a proof of identity and/or a proof of intent.

Signatures do not provide absolute proof of identity or intent but are helpful in establishing mutual trust between two or more parties. These parties can be people or things.

Humans have used written signatures for at least 40,000 years. Cave paintings are an early example still available for us to study today

Digital signatures as an extension of traditional Signature functionality
Digital signatures provide an additional mechanism by which a signature exchange can take place, establishing a degree of trust between two entities. The level of trust is dependent on the uniqueness of the signature. A signature can be made more unique and therefore more secure if a number of identifying properties can be combined. For example, a PIN number can be combined with fingerprint recognition and iris recognition and voice recognition.

The purpose of this Technology Topic is to explore some of the signature recognition capability already available in cellular phones and potential future capabilities.

Radio Signatures
When you turn your cellular phone on, the first job that the phone has to perform is to find a radio system it can talk to. A GSM phone scans a number of pre assigned signalling channels each of which contains a 'beacon channel', a time slot of a prescribed length with a prescribed pattern of 0,s and 1's that the receiver can capture and recognise. A similar process occurs in CDMA. The 'shape' of these short data bursts is in effect a 'phase argument' or 'phase change signature'.

Once the receiver has logged on to the 'beacon' burst, it can go through the process of logging on to the network using various digital identifiers, the equipment identity number and/or SIM based authentication codes.

Radio system signatures have been around for at least 50 years. CTCSS (Continuous Tone Controlled Sub Audio Squelch) is one example. CTCSS uses a group of 16 tones beneath the audio pass band (between 67 and 250 Hz) to divide out different user groups in a private radio system. It is still widely used today.

Radio signatures include of course reflected radio signatures, the basis of radar (radio detection and ranging) systems. Radar systems come in various shapes and sizes, from a few MHz to 300 GHz, from wide to very narrow pulse widths and from

low to very high power. The bandwidth, frequency and pulse width determine the range and resolution. Long 10 to 50 microsecond pulse widths are typically for imaging and .1 microsecond pulse widths for penetration.

As with all things electronic, radar systems are getting smaller. The radar guns used by the police being one example. Even reasonably sophisticated radar systems are now becoming portable. The radio signature from these systems is a function of the polarity, strength and delay of the returning signal and can be used to identify specific objects moving across the radar's field of view.

It is useful for example to be able to tell the difference between a fox, a milk float (van) and a tank.
Inferencing algorithms can be used to 'disambiguate' information. The fox has a certain size signature, speed and movement signature, spatial and temporal signature (more often seen at night and likes dustbins). The milk float tends just to appear immediately before dawn, moves slowly, is a peculiar British institution and is now a rare and threatened species. Tanks are tanks and can appear anywhere any time. They also have a particular audio signature, as do foxes and milk floats.

The combination of these multiple signatures delivers useful and valuable additional 'intelligence'. A UK company, Plextek have a portable radar system that delivers at least some of these capabilities.

So can I have a radar in my cellular phone?
Well in a sense you already have in that the receiver is tracking and correcting for phase shifts and frequency shifts and Doppler shifts introduced by the mixture of direct and indirect received signal paths. It is also transmitting a radio signal though not in a format that is particularly useful for object detection or ranging. There are however systems, particularly systems based on Ultra Wide Band radio transceivers, optimised for micro positioning that can provide accurate (within 6 inches/15cm) 3D object tracking. A company called Ubisense is active in this area.

Other forms of radio signature detection
Conveniently and rather remarkably, humans radiate radio energy in the terahertz band (between radio waves and the infra red band).

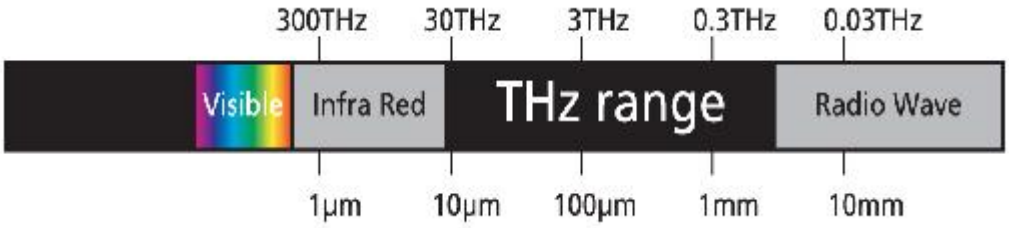

Figure 1 *The Terahertz Radio Band- figure courtesy of Thruvision*
http://www.thruvision.com/

This provides the opportunity to develop passive object detection systems. This is not an application that is likely to arrive in your cellular phone in the foreseeable future but does provide an example of some of the future applications that are being made

possible through the use of ever more sophisticated high frequency radio receiver technologies combined with advanced signal processing techniques.

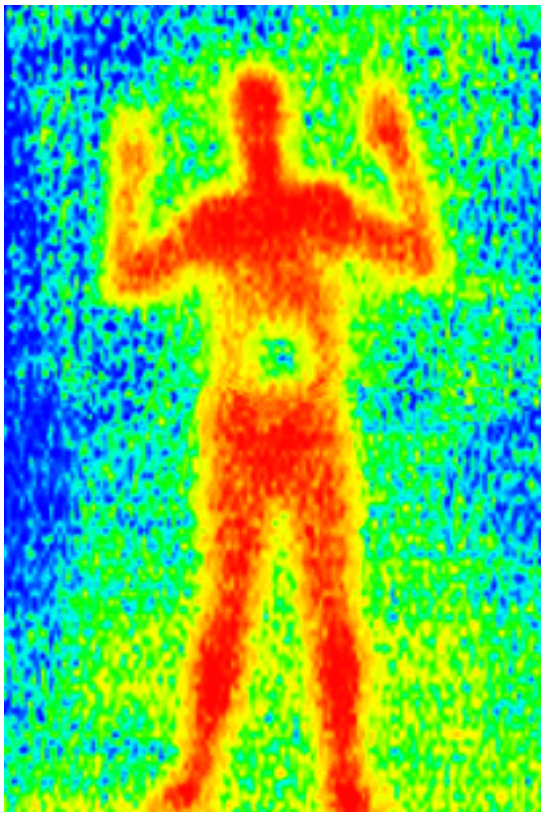

Figure 2 *The use of the Terahertz band for object detection, using passive radiation detection techniques- picture courtesy of Thruvision* **www.thruvision.com**

Audio Signatures

Apart from the fox and the milk float and the tank, most people and many objects have audio signatures. Big Ben, referenced in last month's Technology Topic has a unique audio signature; the sea has a range of unique audio signatures. Tunes have unique signatures, a composite of the key signature and note structure.

Ring tones, particularly user generated ring tones are personal audio signatures, our voice is an audio signature.

Audio signatures can be either within the audio pass band of human hearing or below it or above it. Ultrasound signatures can be used to control lighting for example. A gong is struck mechanically at a specific frequency. The advantage is that no power is needed apart from the physical effort of striking the gong. The disadvantage is that these systems can be prone to interference and false triggering

Essentially there are many applications that can be built on top of either audible or non-audible tone signalling and we can expect a number of innovations in this area particularly as MEMS based solid state speakers and microphones become more common. The advantage of MEMS based solid state microphones and solid state speakers is that they can be integrated with the other inputs that the MEMS devices

can collect, for example motion and pressure. Multiple microphones can be used for noise cancellation and to provide spatial separation of the audio signals received. Multiple speakers can be used for audio beam forming. This suggests a longer term opportunity to develop simple sonar (sound navigation and ranging) functionality.

Akustica are one company presently developing innovative audio 'sensory silicon' solutions for cellular handsets, which promise to deliver some intriguing future user experience differentiation.

Positioning Signatures
These include the UWB systems already referenced and MEMS micro positioning systems. The future value in these systems may lie in their integration potential, the bringing together of local area (UWB/MEMS) and wide area (cell ID, GPS, A-GPS or OTD based) systems. Positioning signatures are a function of a composite of inputs which includes position, direction, speed, altitude.
A recent presentation from an insurance company highlighted how GPS and MEMS based information collected from a car could be used to develop a unique 'driving signature' profile which differentiated 'good drivers', drivers who anticipate and therefore rarely swerve or break or accelerate sharply, from 'bad drivers' who do the opposite from very old drivers who do everything slowly. Such information has a profound impact on the calculation of risk and by implication insurable 'value' and can be combined with other temporal and spatial information to provide more accurately costed premiums (with a built in reward for good behaviour). This may seem peripheral but these are the generic applications bridging consumer and professional markets that will drive future 'bandwidth value 'in radio networks.

Imaging Signatures
Image recognition and pattern recognition can be something as prosaic as the use of a camera phone to read bar codes or the ability to recognise real life objects and people. These applications are becoming available in higher end phones and are a consequence of the increasing resolution now available from CMOS and CCD sensor arrays.

As the noise performance and sensitivity of sensors improves, good imaging including colour imaging can be achieved at light levels (one lux or less) where human eyes start to lose colour and detail. CMOS and CCD sensor arrays will also capture light in the infra red band and the ultraviolet band. In other words they have a response curve that is potentially substantially wider than the human visual response curve. There are a number of light based detection and ranging (LIDAR) application opportunities, the use of infra red for ranging in digital cameras being one example.

Image signatures are the basis for pattern recognition. Pattern recognition is already a widely used technique in digital cameras. Last month we referenced how a high end Nikon digital SLR looks at an image and compares the image statistics with 30,000 pre stored images in the camera, using the information for auto white balance and auto exposure calculations. Image statistics, or in other words image signatures, are the basis for most other adaptive functions in the image signal processing chain including auto focus and edge sharpening algorithms.

Still images can of course show movement, for example the distance of the blur in a

speed camera directly correlates with the vehicle speed, which is why those white lines are painted on the road. Moving images also have unique signatures, sometimes known as the optical flow axis, which feed into movement detection and movement analysis algorithms.

Data Signatures
In our five value domains, radio, audio, positioning, imaging, data, we rather arbitrarily divide the data component into corporate information management and personal information management. Almost any data centric application has a unique signature. The data set from a spreadsheet will have a different signature from a Power Point presentation. We said glibly earlier in this Technology Topic that it was probably implausible for phones to develop an advanced sense of social awareness or 'social sensitivity'. However, a phone does have a number of ways of knowing what we are doing at any given moment. We may for example be multi tasking, talking on the phone, looking at a spread sheet and driving, probably not a great moment to add in a call waiting message. Application awareness has a value. When integrated with other parallel radio, audio, positioning and imaging information, this value is potentially much greater.

Other sensory signatures
We have called this Technology Topic 'Sight, Sound and Cellular' focusing on the use of the visual and audio sensing properties that are being added to cellular phones. Aristotle defined five senses, sight, hearing, touch, smell and taste, a list greatly extended in the 1920's by Rudolf Steiner to include balance, movement, temperature and a sense of pain and wellness. It might seem superficially ridiculous to consider adding smell and taste to a cellular phone. In practice, over time, as chemical analysis techniques improve, it is not inconceivable that certain functionality in these areas might deliver useful value. A phone that could act as a smoke alarm for example would not be too ridiculous.

The realisation of signature value
Signature value is a component of user value.

User value translates into network value, which translates into handset value, which translates into semiconductor value so the topic is of generic interest to most of us.

Signature value is built on an ability to identify people, objects and situations.

The ability of a 'super phone' to capture a complex context from multiple inputs potentially supports a new generation of inferencing algorithms that will bestow additional intelligence to what was once a relatively simple communications device (the cellular phone),

The challenge will be to harness these new capabilities in a way that can be perceived as delivering tangible user benefits and by implication user value.

We may agonise over some of the privacy issues implicit in these applications but history suggests that if a net gain is achievable in terms of user benefits, then a net value gain will follow.

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