Time-Scales of Perception

This project explores how we as humans perceive our surroundings. Key to perception is the notion of scale, patterned behaviours, and our point-of-view.

The project involves two recording devices, that record both video and sound as tides are coming in, in a location in X London. The recording device is either moving (Bobby), or fixed (Stillman). Having both moving and fixed observation platforms is standard in for example physical oceanography, where we are trying to understand global circulation and its potential change with climate change. There, we observe moored arrays that are fixed, and where we can determine how long it takes for phenomena to travel (see e.g. Ellipot et al (to appear)), or the recording device can be moving inside the phenomenon (see e.g. Lilly et al (2011), Sykulski et al (2016)). The first type of observation in known in applied maths as a Eulerian observation, as it observes fluids passing a fixed point. Leonhard Euler (Figure 1a), was a Swiss mathematician, who formulated the Euler equations that describe such motion in 1757. Lagrange (Figure 1b), the French mathematician, in contrast, formulated Lagrangian mechanics in the 1770s, and can describe phenomena while moving with the water motion.

The notion of a Lagrangian or Eulerian representation of motion of a fluid are perfectly reflected by Bobby (Lagrangian), and Stillman (Eulerian), but can also be interpreted in terms of our notion of perception of an immersed and active participant, versus an objective and separate observer. Motion can also distort the object we are trying to understand, and we have been developing mathematical techniques to undue the effect of that distortion (Guillaumin et al, to appear).

Another interesting aspect of the project is the notion of scale. The sound and images are recorded at a given rate (the sound for instance at 48 kHz), and so our notion of this signal will depend on how “quickly” we see it. Any signal can also be thought of as an aggregation of lots of periodic phenomena, that tell us which periods are most important. For instance, if the waves strike the beach, and come in and out at 1 wave per every 2 seconds, then we expect to see the presence of a period as one cycle per two seconds, which is 0.5 Hz. We notice that this is much slower than the possible recording of at 48 kHz, and so the sound of the waves can easily be recorded. In comparison, bird song normally has frequency content from 50 Hz (infrasound) to around 12 kHz. Other sounds than the waves striking the house where the project is recorded are boat engines, which normally live at less than 100 Hz (very low-frequency content). There is a limit to the lowest frequency you can get out of an observed signal, one over the length of the signal. The more exact you want to be about the frequencies in a signal, the longer time-window is needed. This corresponds to the Heisenberg-Gabor uncertainty principle, one of the most famous results in theoretical physics and information theory. As an example see Figure 2 with typical frequency content. Figure 2a for instance shows lots of smooth changes to the signal (low frequency), which might be expected from an engine or the overall wave sound. Figure 2a also has sudden pops which correspond to extreme local time changes, but is spread over frequencies. Figure 2b shows varying frequency content, where some of it is evolving over time. As an oscillation increases frequency content, we call it ‘chirping’, which is common for example in whale song.

Figure 1: (from Wikipedia) (a) Euler and (b) Lagrange

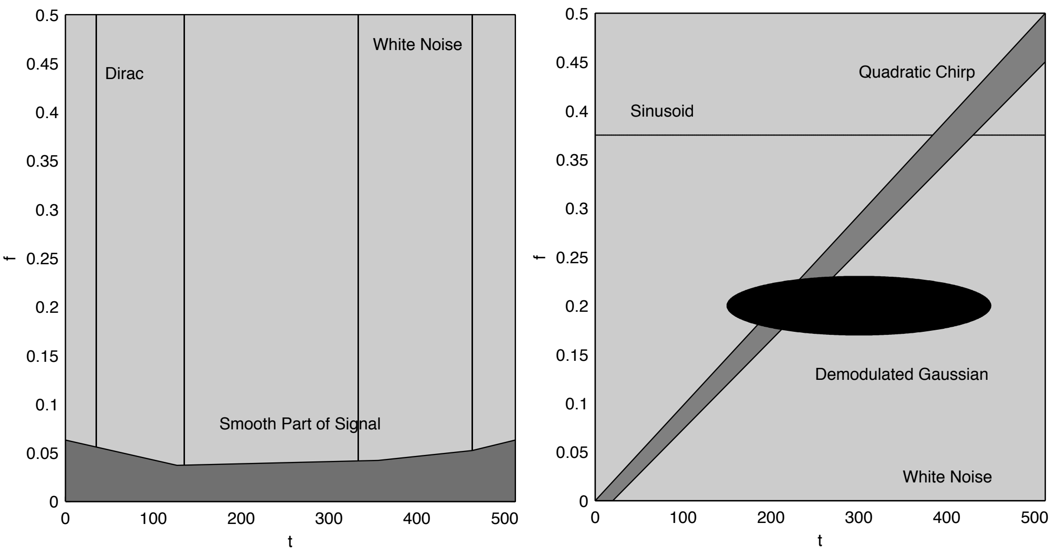

Figure 2: Illustration of the Heisenberg-Gabor uncertainty principle.

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