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Further thoughts on the paper by Baker, Smith, Balleri, Holderied, and Griffiths

# Sensing, Cognition, and Engineering Application

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Definitions of cognition almost always use the term "knowing."Sensors probe the environment producing stimuli that are interpreted to form a perception, but "knowing"is something that takes place within the brain of a human after being presented with sensed data or some form of image. Consider radar and air traffic control. A radar sensor scans the airspace and, using the principles of echolocation, is able to detect, locate, and display aircraft on a screen. An air traffic controller views the screen and continually repositions the aircraft using strict protocols that comply with safety of life requirements. In other words, it is the air traffic controller who supplies the cognitive component necessary to achieve air safety.

Now consider the seemingly different example of blind echolocation experts. Earlier research concluded that all humans, sighted or blind, are inherently able to echolocate (e.g., [1]). Some people have developed this to a remarkable degree and are effectively able to "see with sound."These echolocation experts make a click sound flicking their tongue against their mouth. These signals probe the local environment, and the scattered sound is detected by the delicate and intricate mechanisms of the ear. In the inner ear, neurons are stimulated in a form that captures the structure of the reflected sound signal. The brain then processes these signals likely using inference techniques but within an algorithmic architecture that is parallel, hierarchical, local, and distributed [2]. In this way, a perception is formed from which the blind person is able to know their environment and can interact with it. The complexity of this is immense, yet the end results are a quite remarkable set of abilities. The idea of being able to ride a bicycle down a road full of parked cars without using vision is startling, to say the least. However, some blind experts are able to do this using only tongue clicking. Not only can they detect objects and avoid collisions, but they can also determine shape and texture. This is beyond echolocation sensors such as radar and sonar and provides a dramatic illustration of what might be achievable with a cognitive approach.

In our paper, we described how flow field theory can be applied to echolocation sensors. We also mentioned the example of vehicular radar systems that are fast becoming a standard feature of new cars. Globally, there are approximately 1.3 million road traffic deaths per year. Radars are expected to help in dramatically reducing this figure.

Echoic flow is a measure of time to collision. Safe driving distances can be formulated as time to collision that automatically compensates for both the actual and relative speeds of vehicles. Echoic flow is trivially simple to compute but provides key information for the radar to create an accurate and instantaneous perception allowing automatic adjustments to be made that maintain safe separation. Indeed, any application where two bodies might come into contact can be controlled using echoic flow. This might be to avoid a collision or to orchestrate one that has a desirable form (such as a helicopter landing on the deck of a moving ship). Even more useful is being able to recognize differing categories of possible obstacle. Detection and recognition of humans by vehicular radar is one such example. Blind echolocation experts are able to distinguish between other humans and, say, lampposts. By distilling the processes at play, we can potentially incorporate this into vehicular radar to form a further synthetic perceptual ability. Together with the echoic flow, this has clear and very significant implications for improving road safety. Overall, we are at the very beginning of marrying cognition to sensing. The potential for improving existing capabilities and for generating new ones is immense. h

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