Affect in robots for interaction and control - challenges for the engineer

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Affect, or the expression of emotion, once the preserve of the psychologist, has become an active area of study by Computer Scientists seeking to make the Human-Computer Interface more useable and attractive (Pickard, [9]). Following pioneering work of Cynthia Breazeal (2002) at MIT and others this quest has been extended to robots and robotics.

Initially focusing on the outward appearance of the basic or "universal" (generally attributed to Charles Darwin, [3]) emotional states - happy, sad, fearful, angry, surprised and disgusted - many humanoid robot designs have incorporated mechanical mechanisms to emulate the appearance of emotion. The full range of emotion is far greater than these, there is a challenge to catalogue and express a satisfying set of states. That inanimate objects can be made to appear expressive in this way, to show both these basic and also an impressive range of more subtle secondary emotions is hardly in doubt. In drawings and paintings, cartoons and animations, on stage and screen, the artist, the actor and filmmaker can readily evoke the appearance and sense of affect.

The expression and recognition of affect is universal, but not constant across individuals and there is ample evidence that all but the simplest affective states can be highly culturally dependent (e.g. [10]). With the widespread sharing of media content this will no doubt diminish over time. In the meanwhile the engineer is still faced with two interesting challenges. First, if a life-like facial depiction is intended, to develop materials and control strategies that avoid the unsettling "uncanny valley" effect. Second, if a more abstract approach is favoured, to develop a "visual language" of affect, much as Emojis seek to do for social media, that will be universally acceptable, mostly unambiguous and effective.

Affective communication is naturally bi-directional, as we recognise emotion, we also express it. Programmatic recognition has proved to be altogether a more difficult task. Facial cues (e.g. the work of Pantic and Rothkrantz, [8]) are hard to identify and fleeting, often ambiguous, and can be deliberately disguised or feigned. The challenge to the engineer is made additionally difficult as affect is expressed over many other channels: pose and movement; and in spoken content, tone of voice, and turn of phrase (e.g. [5]).

Why should a robot engineer be interested in affective interaction? It's an essential, integral and inescapable part of the human condition, fundamental to what we are and what we do - even if we don't like to admit it. If robots are to engage with us on a social level - industrial robots need not apply - then surely they should appear to be expressive and at least apparently cognisant of our frame of mind. The jury is still out, but it seems likely that this will make a material difference to the widespread acceptability of social robots. The question remains for both the engineer and marketing expert, as to how this should be achieved: irredeemably cute, perhaps, or seemingly impassive but subtly expressive as with a traditional butler.

How, for instance, should driverless cars be designed to react to agitation or impatience from its passenger? Should it attempt to ascertain the state of mind of human drivers in normal vehicles with which it must share road space? Human drivers must do this continuously and it is likely to become a pressing issue as autonomous vehicles become more widespread.

While potentially immensely valuable, the appearance and interpretation of affect is only part of the robotics task. For most people, emotion is defined by how it "feels", the property of qualia. This is perhaps a task too far for the engineer, being the domain of the new-age writer, neuroscientist,

and philosopher. However, there are many aspects of emotion that are fully accessible to entirely conventional investigation. We can, for instance, ask under what conditions an emotion will be activated. Mueller ([6]), for instance, provides examples couched in a formal logic framework based on the theory of emotion due to Ortony et al. [7].

Once generated, what effects does an emotion have? At a fundamental level it can be regarded as an additional control signal, to modify and possibly drive the body's "cybernetic" control system. Each emotion is self-announcing, we recognise it by a distinctive sensation. It must encroach on our attention. Such distinctive sensations can be anticipated and used to modify planned behaviour. It will certainly modify our interpretation of a situation and our memories of it.

Many have argued that pure reason alone is insufficient to generate the range of behaviours required of a truly "autonomous robot", any more than it would be possible in a human (Damasio, [2]). Planning systems for social robots will be required to select and prioritize goals and select actions to perform with human sensibilities as a primary selection factor. Integrating rational decision making and planning with ordinary commonsense and the consequences of affect represents an ongoing challenge for all working in cognitive robots.

Many of these issues fall within the normal remit of the practicing engineer. However, if we are to construct sophisticated social robot systems then these issues must be addressed, and within the near future. In doing so, should we take care? It is clear, for instance, that human emotion is easily manipulated by the unscrupulous, for individual or commercial gain (e.g. Hochschild, [4]) or in an attempt to achieve social consent.

If we are to believe the vast majority of science fiction literature and cinematic output, we certainly should take care. From the earliest examples, Karal Čapek's 1927 play "Rossum's Universal Robot's" or Fritz Lang's 1927 film "Metropolis", through to the latest Hollywood output, imbuing robots with analogues of human emotional traits has invariably ended badly. But these are, of course, fictional dramas made only to entertain us. Unfortunately, such dramas, however far fetched and disassociated from research reality, play exactly to the anxieties and concerns of the wider non-technical public. The social challenge to the engineer is to contain and manage those expectations while still addressing the technical and commercial challenges that lay ahead for social robotics.

Overall, the key, and most daunting, challenge for the engineer must surely be to understand and exploit the useful attributes and advantages of affect in robots in all its forms, without them falling prey to the extremes apparently inherent in the human condition.

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