Basic Communicative Acts (BCAs): A Strategy for Implementing Context-Sensitive Dialogue in Social Robots

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Introduction

Verbal interaction among humans is a dazzlingly complex process, requiring integration of a number of cognitive competences like the faculty of language, semantic memory, scene understanding. Theory of Mind, interactional alignment, cultural knowledge, and more (Levinson 2006). Most researchers in the fields of computational linguistics and human-robot interaction (HRI) believe that we are still decades away from human-like interaction capacities in machines. An important question is whether all the mentioned faculties will have to be implemented at once in order to enable a natural interaction experience for the human user, or whether it is possible to realize a simple yet realistic type of ‘basic’ interaction competence in the nearer future, then gradually enrich it in order to implement human-like skills at a later point in time.

Drawing on evolutionary research

As a researcher with a background in the cognitive and life sciences, I want to propose that a potentially promising strategy for achieving this kind of cumulativity is to draw on current knowledge of human and primate evolution (from fields such as evolutionary psychology and paleoanthropology; (Tomasello 2008)). In this short paper, I shall confine myself to one example which stems from my own research: the example of ‘basic communicative acts’ (BCAs, see (Reich 2010)).

What is a BCA? A BCA is a primitive, culturally universal and evolutionarily ancient type of communicative act that can usually be realized by both verbal and gestural signs. An example is the BCA-type affirmation, which can be realized by a nod in most European countries, a wavy head-shake in rural Bulgaria, and specific verbal messages in all languages – thus, the act-type is universal whereas the signs that convey it are culturally relative (a more technical definition of BCAs is given in (Reich 2011)). A (presumably incomplete) catalogue of BCA includes: object-offer, object-request, imperative pointing, declarative pointing, hush, ego-attention, summons, relocation, affirmation-request, affirmation, rejection, approval and inhibition / prohibition (Reich 2011). Figure 1 illustrates five types of BCAs.

Despite their simplicity, BCAs rest on ‘Gricean’ (i.e., overt) intentionality – they are ‘on record’, that is, meant to be understood. Current research suggests that this characteristic implies that they are species-typical in humans but not in the great apes (except for object-request, i.e., begging). It also suggests that they evolved in genus Homo 1-2.5 million years ago in order to support communicatively coordinated cooperation, such as coordinated hunting, tool-making and teaching of the young (Reich 2011). This means that they emerged before language and likely constituted an interactional infrastructure on which first protolanguage, then compositional semantics and recursive syntax, were able to evolve. It also means that their production and comprehension is much simpler than full-fledged verbal interaction, because early species within Homo (with a neocortex size in the range of contemporary great apes) must have been able to master it. Indeed, even some domestic animals species (dogs, goats etc.) have been shown to have innate abilities to decode a subset of the signs that typically convey BCAs, such as pointing gestures.

Towards algorithms for BCA-comprehension

BCAs are promising for realizing the aforementioned, cumulative research strategy within HRI because they are non-linguistic acts (Vicars 2001) that can, nonetheless, be used to convey sophisticated and context-sensitive pragmatic meanings. Thus, a robot that can comprehend BCAs from a human user is potentially able to participate in cooperative interactions, even if it does not comprehend language in the strict sense of the term (Nguyen and Kemp 2008).

If we thus factor out language (initially), comprehension must chiefly rely on context. What challenges exist with regard to the implementation of context-integrating algorithms for BCA-comprehension in an embodied machine, such as a robot? Even a preliminary answer to this difficult question would require a comprehensive survey of the cognitive-scientific literature on action understanding and communicative comprehension, which is not possible here. Instead, I want to put forth the following three hypotheses which inform my own present work on BCA-comprehension. Many

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additional challenges exist, but most have been covered in depth in the existing literature.

1. BCA-comprehension needs sophisticated object recognition. Research on mirror neurons and embodied cognition has shown that primates generally perceive objects in terms of the action affordances they furnish to nearby individuals (Rizzolatti and Sinigaglia 2008). Such affordances are heavily exploited in BCA-comprehension (e.g., see Figure 1.a).

2. BCA-comprehension needs sophisticated activity recognition. Defined activities constrain the cooperative role which the sender of a BCA wishes the target to fulfill in virtue of the BCA, thus permitting the addressee to determine the overtly intentional (‘Gricean’) goal behind the BCA (e.g., Figure 1.d).

3. Although this is frequently assumed, BCA-comprehension does not necessarily need social meta-reasoning. In cooperative encounters, BCA-comprehension rests primarily on the recognition of surface features rather than recursive inferences about mental states (‘She thinks that I think that she...’). In contrast to older work on computational pragmatics, current research on BCA-comprehension can therefore focus on applying modern techniques for pattern recognition and machine learning.

Tackling these hypotheses, even in the constrained context of BCA-based communication, will not be an easy undertaking but a worthwhile one, requiring further cooperation between HRI and cognitive science.

References