Contexts, Co-texts and Situations in Fusion Domain

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Abstract—“Context” is a widely used term, but its use stills suffers from either generality or incompleteness. This paper reviews the two main contrasting theoretical paradigms on linguistic contexts, provides some materials for reasoning about the different ways we use the term “context” in everyday life and in fusion domain, and proposes the use of distinct terms to denote different conceptual levels.

Keywords: Context, situation, natural-language understanding, multimodal communication.

I. INTRODUCTION

“Context” is a widely used term, by anyone in everyday communication as well as by philosophers and scientists with many different definitions. Since Dummett, we speak of the “context principle” in Frege and Wittgenstein: “An expression has a meaning only in the context of a sentence”. The context principle finds an extension in some of Wittgenstein’s ideas, especially in his famous passage where he says that “to understand a sentence means to understand a language” (Wittgenstein [1]). What is usually meant by “context” is definitely itself “contextual”. Active research devoted to “context” modeling and management can be found in contemporary Semantic Web [2] as well as in Ubiquitous Computing or Context-Aware Computing [3] domains, and, traditionally deeply investigated, in Philosophy of Language, Linguistics, Pragmatics [4], [5].

The notion of context is also widely studied in different areas of AI. Perhaps the first reference to context in AI can be traced back to R. Weyhrauch and his work on mechanizing logical theories in the interactive theorem prover FOL [6]. However, it became a popular issue only in the late 1980s, when J. McCarthy proposed to formalise context as a possible solution to the problem of generality [7].

In Data Fusion (both “hard” and “soft”), real world contexts, in terms of state of affairs, as well as communicative contexts, are a necessary key element to be considered to refine ambiguous estimates, explain observations, constrain processing [8], therefore dealing with all possible aspects of context.

In this paper we will investigate some theoretical territories, mainly in the linguistics field, to obtain a possible common definition and a consistent terminology which could be useful in boosting context research in the Fusion domain.

II. THE “STANDARD” DEFINITION AND SOME KEY EXAMPLES

A. Language

When we search for the term ‘context’ in a dictionary, here follows what we usually find

Context: 1. The weaving together of words and sentences; construction of speech, literary composition.
2. The connected structure of a writing or composition; a continuous text or composition with parts duly connected.
3. The connections or coherence between the parts of a discourse.
4. a. concr. The whole structure of a connected passage regarded in the bearing upon any of the parts which constitute it; the parts which immediately precede or follow any particular passage or “text” and determine its meaning.
4. b. transf. and fig. [9].

As expected, apart from the reference to figurate meanings reported in point 4.b, the definition deals with the direct relationship between “context” and whatever “text”. Let’s start therefore from some linguistic examples.

(1) The cat caught the bird and ate it.

In sentence (1), the pronoun “it” has an anaphoric function. The referential link between “it” and “the cat” must be recognized to understand it and to evaluate the truth conditions of the same sentence. The same happens with the pronoun “he” in sentence (2) apart from the fact that it precedes its referent, playing a cataphoric function.

(2) Because he was very cold, David promptly put on his coat.

But what about next sentence?

(3) The cat ate the bird and it died.

Evidently the content of sentence (3) itself is not enough to understand it and we need to have some other “external” knowledge. We are also aware that the truth value of a sentence like (4) changes. It can be true for some pairs \(\langle\text{location, speaker}\rangle\), false for others.

(4) I’m talking about context here.
Actually not only the truth value, but even the content (“what is said”, see [10]) varies: think about a professor of English literature uttering (4) during a class on Shakespeare drama on December 12, 1980, about a student of Formal Semantics taking an exam on July 8, 2000, and about an analyst trying to understand what’s going on in a social network on March 14, 2011.

A set of instructions like

(5) “At the third block turn right. After three blocks turn left and stop at the first traffic light”

describe different paths on a city map, depending on the starting point. The set is compatible with some path which start from different initial locations (P1 and P2 in figure 1). However, it is not compatible with many other starting locations (P*). The use of the map presupposes that an agent knows her/his position, or that the map can be used to locate the actual position.

(6) Holmes lives in 221B, Baker Street.

Sentence (6) is true in the (fictional) contexts of Conan Doyle’s stories. It is a false representation of the real world, in which at that address there was the Abbey National Building Society. The fictional context of the Sherlock Holmes stories contains a lot of facts that are false in the real world, however in order to understand the stories, we have to use a big amount of real world knowledge, “importing” it into fictional world, even if it is not explicitly said in the stories. This means that it implicitly assumed a relationship between the two contexts.

(7) The Italian Prime Minister is from Bologna.

Sentence (7) is false in the context of our knowledge and believes (we know that the current Italian Prime Minister is Mr. Berlusconi who is not from Bologna). However it might be true in the context of believes of some person who has been segregated for years and does not know that Mr. Prodi - who is from Bologna - is no longer the Italian Prime Minister.

B. Denotations and connotations of depicted objects

In the semiotic domain the central term “text”, is applied not only to linguistic texts, but in its broader understanding to any meaningful sequence of signifying elements organized by a particular underlying “language”, thus, images or films could be regarded as texts, too.

Let’s for example think about the concept “necktie” and think about the richness of its semantic-pragmatic domain. A “necktie” is a piece of clothing associated, in our culture, with some dress code, it has “fashion” connotations. It has a form, dimensions, and texture; it is worn on the body. In principle all the connotations pertaining an uttered word could be evoked, probably not in the same way for any person, and the same we expect to happen looking at a pictorial representation of the same object the word denoted. However, a picture can only depict some specific object, for example the necktie, and that specific necktie, even if it is pictorially “decontextualized”, does not only share connotations with other “decontextualized” neckties but also has connotations differing from them. The following example, whose structure we owe to [11] will clarify the concept.

Look at figure 2.A.1, it can be considered without doubt a prototypical necktie, which, despite the absence of any context, lying on a black background, conveys some connotations of elegance, of visual pleasure etc. Compare this to figure 2.A.2, which too looks like a rather prototypical necktie. This is not a photograph but a drawn picture of a necktie and the connotations proposed for the necktie in 2.A.1 do not adhere to the necktie in 2.A.2, a probable connotation here is arguably that it is an item in a list or a knot schematics.

In the next picture, figure 2.A.c, the represented necktie is similar to that in 2.A.1 in being once more a photographic representation, but different in the sense that it is a different kind of necktie. It shows to be connected to some uniform thus evoking, together with “elegance”, the “belonging to a house”, the loyalty owed to it, the pride of wearing it, etc.

While the connotation of “belonging”, and somehow also of “pride”, seems to be conveyed by the necktie in figure 2.d, too, the connotation “elegance” may be here reduced because we recognize that this is a geek necktie. So among the potential associations activated here are “nerd”, “geek”, etc.

Here is another example: a series of visual representations of “dog collars”. While dog collars prototypically connote dogs, individual dog collars may elicit specific associations. The dog collar in figure 2.B.1 looks very ordinary (it is worth noticing...
that “ordinariness” is in itself a potential connotation. Figure 2.B.2 shows a dog collar that is less straight, it is pink and it looks like to be worn by a little “pet” doggie. The most eye-catching characteristics of the dog collar in figure 2.B.3 are the spikes and pyramids and connotes “ferocity”, most certainly the “pet” dimension here is almost non-existent. The example in figure 2.B.4, finally, is definitely different from the others. It can be defined (and actually is defined so) a dog collar just because it is worn by dogs, but the tool functionality and purpose here changes from “physical” to “virtual” control.

Now, the similarity between neckties and dog collars could serve as basis for a pictorial metaphor [12]. There is no “natural” way in which features from both domains of neckties and collars are to be matched. Which features can be matched will depend on the context in which the metaphor occurs and different combinations of features will lead to different “emergent properties”. In figure 3 for instance, it can be recognized, through the gesture context, the metaphor THIS NECKTIE IS A DOG COLLAR.

Figure 3. This necktie is a dog collar.

All the examples we considered above, together with some possible others on presupposition, implicatures, indexicals and demonstratives which can be found in [13], lead us to some considerations:

- Any representation may depend on a lot of implicit assumptions.
- We are not always aware of these assumptions, but we are often required to reason about them.
- There is not such a thing as the ‘right’ representation: different state of affairs may require to leave implicit or make explicit different collections of assumptions.
- Of the ‘same’ fact may be given different representations in different contexts/situations, and these representations are somewhat related.
- Context can be found both “inside” or “outside” the state of affairs under consideration and both “inside” or “outside” its representations.

III. TWO GENERAL CONCEPTS IN THREE DEFINITIONS

In the next three Subsections, three definitions of different forms of context will be presented, recognizable as a combination of two main concepts, namely

1) Context is a mere collection of features of the world
2) Context is a representation of features of the world.

A. Objective Context

Objective Context (also defined Metaphysical or Semantic) consists in the state of affairs in the actual world, a set of features of the world, relative to an utterance, or context of the utterance. Following Kaplan [14], one of the best advocates of this kind of concept, we can give a formalization of such a concept with a tuple of parameters (speaker, time, place, . . .), which actually had been embedded in a model-theoretic semantics, and represents the metaphysical state of affairs or what “there is”.

“Context is a package of whatever parameters are needed to determine the referent […] of the directly referential expressions” and “each parameter has an interpretation as a natural feature of a certain region of the world” Kaplan [15].

In Kaplan’s treatment of objective context is implied a distinction of at least two levels of meaning, defined ‘character’ and ‘content’, that is linguistic meaning and truth conditional meaning, along the traditional analysis of mathematical logic.

Another way of considering objective context is Perry’s [16] semantic context, to be identified with what is needed to give an evaluation to indexical expressions, after disambiguating the literal or linguistic meaning of the words.

B. Pragmatic Context

Pragmatic Context (also defined Subjective or Cognitive) concerns a point of view of a situation, or a theory in which a situation can be considered or described. This notion is apt for example for distinguishing the different meaning of some mathematical or logical formula depending on the theory in which the formula is used. Aspects of cognitive context have often been included in the objective context, which may be thought of as also including mental states or beliefs of the speakers.

A cognitive characterization stresses the theory-laden aspect of the cognitive context. From this viewpoint, cognitive context can be represented as a local theory consisting of (Language, Axioms, Rules).

This idea has been developed by McCarthy [17] and Giunchiglia [18], with the basic motivation that for every axiom a more general context can be found, where the precise form of the axiom does not hold (the so-called problem of generality); and for any situation, it is worth using the smallest possible amount of information to reasonably treat any problem avoiding combinatorial explosion (the so-called problem of locality).

Any interpretation and evaluation of utterances therefore needs a defined cognitive context in which the utterances receive both meaning and semantic value. This point of view differs from that of objective context typically aiming to give a defeasible point of view (of individuals, groups, institutions, databases...) about a situation, while objective context aims to give the objective features necessary to evaluate an utterance.

C. Discourse Context

Discourse Context (also defined Dialogue or Conversational) theory postulates that the description of a conversation...
needs to refer to an objective context of utterance, that is
speakers, location and time of the conversation and a represen-
tation of the different cognitive points of view or background
assumptions of the interlocutors. Therefore, at first sight, it
seems that treating discourse context requires both objective
and cognitive context.

Discourse Representation Theory (DRT) [19] began by
developing a theory of discourse context, where the repre-
sentational structure of the elements of discourse worked as
the context in which to interpret any new following sentence,
as sentence (8) is interpreted with the structure \( K_1 \).

(8) A man got in, he sat down.

\[
\begin{array}{c|c}
\text{x} & \text{y} \\
got\text{in}(x) & \text{sat\_down}(y) \\
\end{array}
\]

\( K_1 \)

Stalnaker [10] on the other hand seems to follow the
opposite path: he begins with a possible-worlds semantics to
recognize the need and the importance of syntactic structure.
He gives therefore a double representation of discourse context
consisting of shared information about the subject matter of the
discourse, represented in a possible-worlds semantics and of
facts about the discourse, including syntactic aspects, which
need to be taken into account (e.g. the specific language in
which it is produced).

IV. MANAGING THE TWO POINTS OF VIEW

The two interpretations seem to correspond to two contrasting
philosophical positions and two consequent different kinds
of formalism:
a. the metaphysical theory is an expression of realism or
objectivism, usually connected to model theoretic semantics
(particularly with direct reference theory and with the
double indexing);
b. the cognitive theory is the expression of an anti-realistic
attitude typical of cognitivism and subjectivism; it is connected
to computational solutions.

The question, then, regards whether one of the two points of
view leads to better solutions or at least to better perspectives
or the two can be integrated or one reduced to the other.

A. Separation, Integration, Reduction?

The theory of the metaphysical context has been designed in
order to deal with the peculiar logical behavior of indexicals.
In classical semantics it was impossible to give a correct
semantic value to sentences with indexicals because of their
dependence on context. The classical example given by David
Kaplan:

(9) I am here now.

is a sentence which is always true; however, its truth is
not necessary, because it is not true in all possible worlds: of
course I might have been somewhere else.

Kaplan [14] proposed a solution for the formal treatment
of this kind of sentences. We have to distinguish between
two indexes at which sentences are to be evaluated: on the
one hand, at all pairs of a moment of time and a possible
world (circumstances); on the other hand, at speaker, time and
location (contexts of utterance).

From this work onwards logicians began to speak of “dou-
ble indexing” to indicate this kind of semantical evaluation.
Double indexing is a tool to evaluate two different aspects
of indexicals: one aspect deals with the objective context
of utterance, and it evaluates the linguistic meaning of the
indexicals, the “character”, intended as a function that
-given the context - gives the “intension” or “content” of the
indexical. For example the character of “I” will be a function
which gives, depending on each context, the way to refer to
the speaker of the utterance in any possible world. It will
give the “intension” of “I” as used in that context, that is
the constant function which gives the same individual at each
possible world. In short, Kaplan develops the main idea of
model theoretic semantics (the meaning of a sentence (its
intension or content) is its truth condition), enriching it with
a new level of semantic analysis, the level of character. While
content or intension is a function from possible worlds to
extensions, character is a function from contexts to contents.

The theory of cognitive context, on the other hand, has
been devised in AI to solve a problem of commonsense
reasoning. After the attempts based on non-monotonic logic,
especially circumscription, McCarthy thought that the problem
of generality was still unsolved.

Any system of axioms can be transcended: we may always
find a wider context where the axioms are not valid. Therefore,
we need to keep in mind the cognitive context in which we are
reasoning and make every assertion relative to a context.
In order to realize this, we may use operations or rules among
contexts, such as:

- entering and exiting a context,
- discharging some sentence, true in some context, but false
  in a wider context:
- lifting some sentence true in some contexts into another
  context, verifying in this way different kinds of compat-
  ibility among contexts.

Another aspect has to be taken into account, which could
be called “principle of laziness”. We use the minimal set of
information needed to solve a problem, importing information
only when new facts come to the scene. Reasoning is always
“local” to some context. In order to solve a problem due to
some novel information we can always create a new
context (“working context”), importing information from other
contexts: stereotypical contexts, databases, partitions of knowl-
edge representation. The basic principles behind this strategy
are the principles of locality and of compatibility. In short,
the two principles mean that, on the one hand, reasoning is
always local and, on the other hand, most contexts share rules,
strategies and information which provide a general framework
for defining contexts as a rich formal object, a new tool for
the analysis of reasoning.
Actually, McCarthy remarks that we cannot expect a definition of the concept of context in AI. We cannot expect to know what a context is: “instead, as is usual in AI, various notions will be found useful” ([17], p.1). Still, in most works on contextual reasoning contexts are regarded as assumptions associated with some circumstance; we shall therefore keep the distinction between contexts (sets of assertions representing the cognitive state of an individual or a group) and situations (states of the world at a certain time).

The difference of aims and problems to be solved by the two kinds of theories could promote their separation: they have different purposes, different logical environments, different formalisms. But there are also possible interconnections between the two theories; it’s been considered, for example the possibility of including a speaker’s beliefs or background knowledge in the index, so that indexes could become somehow “cognitive”. And theories of cognitive context have to face the problem of the context of utterance; dealing with commonsense reasoning, they have to cope with indexicals and demonstratives.

B. Avoiding context dependency?

A radical solution to the problem of dealing with contextualized sentences could proceed from the following anti-contextualist claim (10)

(10) For every statement that can be built using a context-sensitive sentence in a given context, there is an eternal sentence that can be used to make the same statement in any context.

To obtain an eternal sentence from a context-sensitive one it is necessary and sufficient to replace the indexical constituents of the latter by non-indexical constituents with the same semantic value. Using natural language, we could behave so as to abolish the difference between natural languages and the formal languages, in which the context of utterance plays no role, simply by choosing to utter only eternal sentences.

But people usually adopt context-sensitive sentences because this “allows speakers to speak far more concisely than otherwise. […] Pragmatics saves us from […] wastefulverbosity” (Jerrold Katz [20]: pp. 19-20).

A stronger principle of effability, namely (11), moves from statements to thoughts:

(11) Every entertainable thought may be expressed by means of an eternal sentence the sense of which corresponds exactly to that thought.

Many philosophers have argued against (11). For example, Sperber and Wilson write:

“It seems plausible that in our internal language we often fix time and space references not in terms of universal coordinates, but in terms of a private logbook and an ego-centred map; furthermore, most kinds of reference - to people and events for instance - can be fixed in terms of these private time and space coordinates. Thoughts which contain such private references could not be encoded in natural languages but could only be incompletely represented”. (Sperber and Wilson [21]).

Claim (10), however, is not subject to such a criticism. It affirms only that, form example, some statements about a certain object does not necessarily involve a particular mode of presentation of that object. The fact that, in the thought, there are private modes of presentation attached to the objects referred to implies that there are thoughts that cannot be totally and adequately represented by means of eternal sentences, but does not imply that there are statements that cannot be made by means of eternal sentences: statements are public objects at a more abstract level than thoughts, and as such do not contain private modes of just “presentation”.

A critical point, although, if we consider claim (10) in a domain like fusion where real life and state of affairs are the object of investigation and processing, consists in the fact that producing such eternal sentences implies in any case to make explicit the necessary tuple of features, that is, implies a process of context understanding.

V. ONGOING RESEARCH

As seen in the introduction “context” is a necessary concept in Ubiquitous Computing, Context-Aware Computing and Semantic Web domains. Some papers like [22] provide a survey of the most relevant approaches to modeling context for ubiquitous computing, classified relative to their core elements and evaluated with respect to their appropriateness for the domain. Results show that the most promising assets for context modeling for ubiquitous computing environments can be found in the ontology category.

In the Semantic Web domain, several paradigms, tools and languages have been proposed with the aim of adding context awareness. That is, enabling representation and reasoning not only with the knowledge alone, but also with the associated contextual information such as time, topic, provenance, reliability, etc. These new paradigms introduce a new dimension into knowledge engineering: in addition to individuals, concepts, properties and their relations, it is necessary to define the set of contexts as much as to “split” the knowledge between these contexts. In [2], the authors propose a novel architecture, the Contextualized Knowledge Repository, completely embedded in standards represented by RDF and OWL, therefore ontologies standards.

In a “real world assessment” scenario, though, the goals are different: the problem is not that of evaluating variables in a model, getting truth values, but that of building and recognizing variables themselves which are going to play a role in the model. Therefore, the aforementioned concepts do not completely fit, as well as the frameworks and tools which have been proposed to deal with them.

In “real world assessment” two main different strands or levels can be recognized:

1) Context is a collection of objects or properties or features of the world exploited to define or recognize and label simple or complex events or situations.
2) Context is a collection of ranging data, sensed in a subset of the world, exploited to build a correct or reliable perception of objects or events.

On one hand, definition 1. is used for example for situation assessment in automotive applications where context consists both in data coming from cameras mounted on vehicles and in other data form sensors measuring steering angle, speed, brakes, etc. The joint analysis of on board/off board car context can be used to derive considerations on driver’s behaviour and then to detect possible dangerous complex situations (driver’s sleep, lane changes, etc.)

On the other hand, definition 2. can be applied to any human as well as machine perception task where properties owned by space-time proximal or causally related objects provide the sensing agents with sufficient information to drop out illusory experiences or, at least, to increase their believes on surrounding world assets.

VI. TERMINOLOGY, A PROPOSAL

The reported concepts and discussions on the general “behavior” of context lead us to draw a model like the one depicted in figure 4.

Context can consist in a bare set of features, like those which answer the questions of a context-aware computing problem (Who, Where, When, What, How and Why), at a real world physical level; or, at a representational level, context can consist in the set of features necessary to bind the variables introduced, for example, by pronouns. We propose to use the term “context” to define the former state of affairs and the term “co-text” to define the latter. “Co-text”, especially common in text linguistics since Petöfi [23], precisely describes the verbal or linguistic context as distinct from situational context. The co-text of an item helps to determine its form and meaning. So-called colligational ties account for the grammatical constraints that fit, for example, appropriate verb forms to subjects. Cohesive devices, such as co-reference, link one part of the text with another; ellipsis too depends on the co-text for its interpretation. Context consists also, probably mainly, in representations of sets of features. We propose to use the term “situation” for any cognitive form of link between real world physical level and representational level.

VII. CONCLUSIONS

In Fusion Domain “context” plays a vital role at any level of a model like JDL, from object recognition through physical context exploitation, to intention estimation through linguistic communication analysis (see also [8]). In this paper we reviewed the main core issues in context exploiting and understanding with the purpose to establish some key points for further research in the field of automatic multimedia analysis starting from the recognition of the different “kinds of context” which can, or must, be taken under consideration in a Fusion problem, and their definitions.

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