

Towards an Ontology for Crowds Description: A Proposal Based on Description Logic

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The research context of this paper refers to bottom-up approaches to *crowd dynamics* that is, the study of how and where crowds form and move [1]. Several phenomena like *crowd aggregation*, *dispersion* and *self-organized movement* have been observed and studied by multiple disciplines interested to crowds (e.g. physics, sociology, ethology, social and behavioral psychology, building design, urban planning, security management, among others), each one with its specific viewpoint and ontological setting. SCA4CROWDS is an interdisciplinary research within this context that aims at contributing towards the development of a unifying ontology on crowds allowing the integration of contributions coming from several disciplines and that could be exploited for scientific and applicative issues (e.g. model comparison, validation, calibration). Potential exploitations of SCA4CROWDS results are towards the support of design and management of public crowded spaces and events to improve security, safety and comfort of people. SCA4CROWDS, in particular, aims at developing formal and computational tools to support the design, execution and analysis of crowds' behavior as effect of individual interactions (e.g. physical, social, emotional) according to Situated Cellular Agent (SCA) [2]. SCA is a modeling and simulation framework to model and study crowd dynamics phenomena with an approach based on Multi-Agent Systems (MAS) and Cellular Automata [3] principles.

In this paper we present the ontological framework for crowds' study we developed according to Elias Canetti work [4], in which a classification and ontological description of the crowd has been proposed as result of 40-years of empirical observations and studies from psychological and anthropological viewpoints. In crowds and CA literature, a formal analysis with CA-based models of theories developed within human sciences context has previously been proposed in [9]. Elias Canetti can be considered as belonging to the tradition of social studies that refer to *the crowd as an entity dominated by uniform moods and feelings*. We preferred this work among others (see for instance [5,6,7,8]) due to its clear semantics and explicit reference to concepts of *loss of individuality*, *crowd uniformity*, *spatio-temporal dynamics* and *discharge*, that could be fruitfully represented by modeling approaches like SCA and Cellular Automata in general. In the following we introduce a formal language belonging to the family of Description Logics (DL [10]) that we propose for the formal representation of conceptual description of crowds and their dynamic phenomena. Description Logics is a family of knowledge representation languages that are used to develop various applications to the issues of data management, including: expressing the

conceptual domain model/ontology of the data source, integrating multiple data sources, and expressing and evaluating queries. First, we define the basic syntax and semantics of the DL language we propose and then we describe, according to this language, basic concepts of Canetti work [4].

1 DL Language for Ontology Representation

A DL language is defined by a set of *concepts*, the elements of the described subject, and a set of *roles* that specify the type of relationships that can hold between concepts. The box on the left hand side of Figure 1 shows the graphical representation of concepts and roles we defined. Atomic concepts (i.e $ENTI \sqcap QUAL \sqcap PSYC \sqcap PHEN \sqsubseteq \perp$) are:

- *ENTI*, entities representing the involved objects;
- *QUAL*, qualities, characterizing an *ENTI*;
- *PSYC*, psychological states;
- *PHEN*, phenomena involving *ENTIs*.

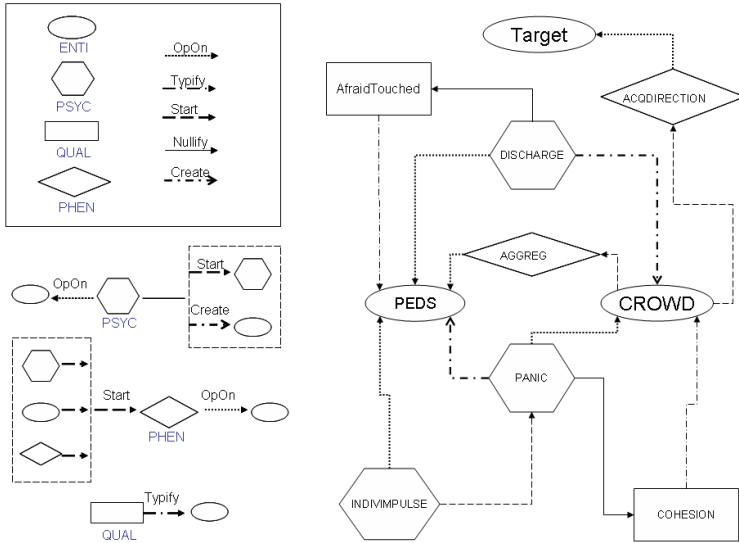


Fig. 1. On the left hand side the graphical representation of the used language basic elements and their relations, composed by the basic concepts and roles shown in the box. On the right hand side a schematic representation of the principal elements of Canetti’s crowd ontology.

All atomic roles, relationships between atomic concepts, are not-symmetrical, transitive, and reflexive (with the exception of *Typify* that is not reflexive):

- *OpOn* specifying that a concept “operate on” another concept;
- *Create*, when a concept is the cause of the birth of another one;

- *Typify* that indicates a concept as an attribute of another;
- *Start* when a concept is the starting condition for the occurrence of another;
- *Nullify* specifying that a concept is the cause of the termination of another.

Language semantics is defined by the following relationships (graphically represented on the left hand side of Figure 1):

- a psychological state (i.e. *PSYC*) is a concept that operates on an entity (i.e. *ENTI*), and starts a psychological state (i.e. *PSYC*) or creates an entity (*ENTI*):
 $PSYC \sqsubseteq (= 1)OpOn.ENTI \sqcap ((= 1)Start.PSYC \sqcup (= 1)Create.ENTI)$
- a phenomenon (i.e. *PHEN*) is a concept that is started by an entity (i.e. *ENTI*) or a psychological state (i.e. *PSYC*) or a phenomenon (i.e. *PHEN*), and operates on an entity (i.e. *ENTI*):
 $PHEN \sqsubseteq (= 1)Start.(ENTI \sqcup PSYC \sqcup PHEN) \sqcap (= 1)OpOn.ENTI$
- a quality (i.e. *QUAL*) is a concept that typifies an entity (i.e. *ENTI*):
 $QUAL \sqsubseteq (= 1)Typify.ENTI$

2 Elias Canetti's Crowd

Elias Canetti's definition of "crowd" can be summed up as follows:

... a unic entity dominated by uniform moods and feelings; it is characterized by the spontaneous will of growing and aggregating other pedestrians, and has a target, that is identified as a location of the environment or an object that all the individuals aggregated into the crowd desire. The *aggregation* phenomenon describes the growing effect that starts from an aggregative psychological impulse called the "discharge". The "discharge" occurs spontaneously in people and overcomes the natural social repulsive behavior of the "fear to be touched". On the other side, crowd disgregation is the result of an other psychological impulse called "panic", rising as the result of "individualistic impulses".

According to the DL language above described, crowd basic entities are $CROWD \sqcup PEDS \sqcup TARGET \sqsubseteq ENTI$, where *PEDS* are "pedestrians", *CROWD* is the aggregation of pedestrians that Canetti considers as a single entity, *TARGET* is the location or the object desired by the crowd. Qualities are $AFRAIDTOUCHED \sqcup COHESION \sqsubseteq QUAL$ (where *AFRAIDTOUCHED* represents the social repulsive behavior, i.e. *afraid to be touched*), and *COHESION* is the crowd desire to remain compact. Psychological states are $DISCHARGE \sqcup PANIC \sqcup INDIVIMPULSE \sqsubseteq PSYC$, representing Canetti's *discharge*, *panic* and *individualistic impulses*, respectively. Finally, phenomena are: $AGGREG \sqcup ACQDIRECTION \sqsubseteq PHEN$, where *AGGREG* represents the "aggregation" phenomenon and *ACQDIRECTION* represents the crowd motion towards its "target". Relationships between concepts are graphically expressed in the right hand side of Figure 1, and in the DL language above defined:

- $PEDS \sqsubseteq \forall OpOn^- . DISCHARGE \sqcap \forall OpOn^- . INDIVIMPULSE$
- $DISCHARGE \sqsubseteq \forall Create.CROWD$
- $CROWD \sqsubseteq \forall OpOn^- . PANIC \sqcap \forall Start.AGGREG \sqcap \forall Start.ACQDIRECTION$
- $PANIC \sqsubseteq \forall Create.PEDS$
- $AFRAIDTOUCHED \sqsubseteq \forall Typify.PEDS \sqcap \forall Nullify^- . DISCHARGE$
- $INDIVIMPULSE \sqsubseteq \forall Start.PANIC$
- $AGGREG \sqsubseteq \forall OpOn^- . PEDS$
- $ACQDIRECTION \sqsubseteq \forall OpOn^- . TARGET$
- $COHESION \sqsubseteq \forall Typify.CROWD \sqcap \forall Nullify^- . PANIC$

3 Concluding Remarks

We presented a formal language belonging to the family of Description Logics that we proposed for the representation of the ontological description of crowds according to Elias Canetti psychological and anthropological studies. The main contribution of this work is to provide a semantically clear reference ontology for crowds' models based on SCA (and on any CA-like approach). The formal definition of such a reference ontology can be exploited, from one hand, for their calibration and validation with available data sets, and on the other hand, for their comparison with other CA-based models. Currently, we are integrating the above presented ontology into SCA formal and computational framework, e.g. to study crowds' aggregation phenomenon.

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