A Fuzzy Ontology for the Classification of Crowds at Concerts

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Crowds’ dynamics
the study of how people behave and move

• **Worldwide Research Network:** PEDESTRIAN DYNAMICS, EMPIRICAL STUDIES IN SOCIOLOGY, ARCHITECTURE & BUILDING DESIGN, SECURITY & CROWD MANAGEMENT, ...

• **Studied phenomena:** crowd aggregation, dispersion and self-organized movements

• Observations and studies by **multiple disciplines** for heterogeneous aims (e.g. physics, sociology, economics, ethology, social and behavioral psychology)

• **Relevant applicative contributions** for, e.g. building design, urban planning, security and safety management
Crowd dynamics

- “The study of how and where crowds form and move”
- Studied phenomena: crowd aggregation, dispersion and self-organized movement, observed and studied by multiple disciplines for heterogeneous aims (e.g. physics, sociology, economics, ethology, social and behavioral psychology)
- Relevant applicative contributions for, e.g. building design, urban planning, security and safety management
- Some common features of crowding situations
  - Complex dynamics may emerge as effect of space sharing and other types of interactions (conflicts on space limitation)
  - “too many people in too little space” [Kruse]
  - Human perception (emergency, panic conditions)
  - Emotions
- Studied Scenarios
  - Individual and Collective Behavior (normal and emergency situations): Pedestrians/Evacuees in Buildings, Consumers in Shopping Centers
  - Organized Spaces for public Events: e.g. Parades, Fairs, Sport Events, Marches
  - The Future: Micro-Scales Dynamics in GIS (Batty)
  - Towards a Crowd Ontology (E. Canetti as reference literature in human sciences theories)
  - Data on experiments, real cases, simulations, interviews, ...
  - Analysis results: patterns, aggregated data, estimations, ...
Crowd profiling at pop-rock concerts

- Formal and computational tools for the study of different crowd phenomenology and dynamics that can characterize pop-rock concerts
- In collaboration with artists and music experts
- Crowds classification approach based on the integration of Fuzzy sets and Ontology technologies (OWL, Protégé, DL, ...)
Social psychology Theories on Crowds
Human behavior of individuals and social collectivities

<table>
<thead>
<tr>
<th>Sociologist</th>
<th>Theory</th>
<th>Principle</th>
<th>Crowd as</th>
<th>Rational behavior</th>
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<tbody>
<tr>
<td>Tarde</td>
<td>Transformation</td>
<td>Group Mind</td>
<td>Unique Entity</td>
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<tr>
<td>LeBon</td>
<td>Transformation</td>
<td>Contagion</td>
<td>Unique Entity</td>
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<tr>
<td>Park</td>
<td>Interactionism</td>
<td>Unrest + Circular Reaction</td>
<td>Unique Entity</td>
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<td>Blumer</td>
<td>S. Interactionism</td>
<td>Unrest + Circular Reaction</td>
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<td>Canetti</td>
<td>Transformation</td>
<td>Discharge</td>
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<td>Allport and Miller</td>
<td>Convergence</td>
<td>Uniformity</td>
<td>Individuals</td>
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</tr>
<tr>
<td>Turner and Killian</td>
<td>Emergent Norm</td>
<td>Emergence</td>
<td>Individuals</td>
<td>yes</td>
</tr>
<tr>
<td>McPhail</td>
<td>Interactionism</td>
<td>Circular Reaction</td>
<td>Individuals</td>
<td>yes</td>
</tr>
<tr>
<td>Turner, Reicher, Stott etc.</td>
<td>Social identity</td>
<td>Self-Stereotyping</td>
<td>Individuals/groups</td>
<td>yes</td>
</tr>
</tbody>
</table>

- “A gathering of individuals that influence one another and share a purpose, intent or emotional state in a limited space”
- “Too many people in too little space” (Kruse, 1996)
- Crowd as form of collective action: “two or more persons engaged in one or more actions, judged common or concerted on one or more dimensions” (McPhail, 1991)
- …
Canetti’s Theory

• In 1960 Elias Canetti wrote “Crowds and Power”, 40 years of empirical observations and studies on crowds’ phenomenology

• He can be inserted in the tradition of studies that considers the Crowd as a single entity, a unity dominated by uniform feeling (contagion theory)

• His analysis comprehends a classification of crowds and considerations from many perspectives (psychological, anthropological, ideological, political…) and proposes a theory on crowd with explicit reference to:
  • loss of individuality, crowd uniformity
  • spatial-temporal phenomena, crowd dynamics

“The Fear of being Touched”
“THERE IS NOTHING that man fears more than the touch of the unknown”
An ontological framework based on Elias Canetti theory on Masses and Fuzzy sets

**The Discharge**

The most important occurrence within the crowd is the discharge. Before this the crowd does not actually exist; it is the discharge which creates it. This is the moment when all who belong to the crowd get rid of their differences and feel equal.

- Literature & KA with domain experts (Polizia di Stato, artists) specialization to crowds at concerts
- Disambiguation of natural language and formal representation in DL
- Fuzzy sets theory to represent not crisp concepts of crowd classification model
Ontology basic concepts and roles

QUAL ⊆ (= 1)Typify.ENTI

PHEN ⊆ ( = 1)Start⁻.(ENTI ▯ PSYC ▯ PHEN) ▹ ( = 1)OpOn.ENTI

PSYC ⊆ ( = 1)OpOn.ENTI ▹ (( = 1)Start.PSYC ▯ ( = 1)Create.ENTI)
The DL basic crowd ontology

\[ \text{Peds} \subseteq \forall \text{OpOn}^- \cdot \text{Discharge} \cap \forall \text{OpOn}^- \cdot \text{IndivImpulse} \]
\[ \text{Discharge} \subseteq \forall \text{Create} \cdot \text{Crowd} \]
\[ \text{Crowd} \subseteq \forall \text{OpOn}^- \cdot \text{Panic} \cap \forall \text{Start} \cdot \text{Aggreg} \cap \forall \text{Start} \cdot \text{AcqDirection} \]
\[ \text{Panic} \subseteq \forall \text{Create} \cdot \text{Peds} \]
\[ \text{AfraidTouched} \subseteq \forall \text{Typify} \cdot \text{Peds} \cap \forall \text{Nullify}^- \cdot \text{Discharge} \]
\[ \text{IndivImpulse} \subseteq \forall \text{Start} \cdot \text{Panic} \]
\[ \text{Aggreg} \subseteq \forall \text{OpOn}^- \cdot \text{Peds} \]
\[ \text{AcqDirection} \subseteq \forall \text{OpOn}^- \cdot \text{Target} \]
\[ \text{Cohesion} \subseteq \forall \text{Typify} \cdot \text{Crowd} \cap \forall \text{Nullify}^- \cdot \text{Panic} \]
Example: basic crowd aggregation

- Pedestrians are affected by the “afraid of being touched” that establishes a social distance between the individuals.
- This social distance is quantified by several theories and it depends from the cultural heritage of each person.
Example: basic crowd aggregation

- The “afraid of being touched” is nullified by the “discharge”.
- The “discharge” is a sort of impulse that affects individuals and creates a crowd.
Example: basic crowd aggregation

• A crowd is characterized by different qualities and phenomena:
  – Pedestrians in a crowd try to stay together (one near the others)
  – A crowd attracts other pedestrians
  – A crowd has a target
Crowd types

attitude to grow:

Open crowds can grow without restrictions to members while Closed crowds are limited by ruled participation (e.g. concert with ticket)

density and equality

Stagnating crowds start their aggregation process towards density increase, while the elements of Rhythmic crowds focus on equality to feel themselves as part of a group

nature of the target

Quick crowds need a near target reachable in little time, while Slow crowds can acquire also a remote goal
Crowd measurable features → Crowd classification

- **Spatial limitation**: e.g. if the crowd is inside a building like a stadium or it is located in open space like a park
- **Attitude to grow**: high when new individuals tend to increase the crowd population continuously, medium, or low e.g. when new individuals enter the crowd population by invitation from crowd members or obtain credentials buying a ticket
- **Density**: high, medium, low according to the number of individuals per unit of space;
- **Movability**: e.g. if crowd individuals move according to external solicitations, like e.g. during a rock concert;
- **Duration**: high, medium, or low according to crowd duration in time;
- **Target closeness**: near, or far according to the time required to the crowd to reach its goal (e.g. leader group exhibition at festivals)
- A deeper analysis of such features allows pointing out interesting relationships among the different types of crowd
Crowd measurable features → Crowd classification

- Attitude to grow, density, duration, and target closeness attributes: **fuzzy sets to describe values of uncertain features**
- Spatial limitation and movability: boolean values

<table>
<thead>
<tr>
<th>Limiti sp.</th>
<th>Aperta</th>
<th>Chiusa</th>
<th>Statica</th>
<th>Ritmica</th>
<th>Lenta</th>
<th>Rapida</th>
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<tbody>
<tr>
<td>Crescita</td>
<td>alta</td>
<td>media/bassa</td>
<td>-</td>
<td>bassa</td>
<td>alta</td>
<td>media/bassa</td>
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<tr>
<td>Vincoli psic.</td>
<td>no</td>
<td>si</td>
<td>-</td>
<td>si</td>
<td>-</td>
<td>-</td>
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<td>si</td>
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<td>bassa</td>
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<tr>
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<td>-</td>
<td>media/breve</td>
<td>lunga</td>
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<td>vicina</td>
<td>lontana</td>
<td>vicina</td>
<td>-</td>
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</tbody>
</table>

**Tabella 4.4: Relazioni tra aggettivi caratterizzanti e tipologie di massa**

**Figure 4.6: Rappresentazione insiemistica M_{CRESCE} ∩ M_{DENSITA} ∩ M_{META}**

**Figure 4.10: Rappresentazione insiemistica M_{CRESCE} ∩ M_{DENSITA} ∩ M_{META}**
Attitude to growth, Density, Target Clossness
Membership functions experimentally designed according to concerts background knowledge

- **FunzioneCrescitaBassa(5, 10):**
  \[ y = \begin{cases} 1 & \text{se } x < 5 \\ \frac{10 - x}{5} & \text{se } 5 \leq x \leq 10 \end{cases} \]

- **FunzioneCrescitaMedia(8, 18):**
  \[ y = \begin{cases} \frac{x - 8}{5} & \text{se } 8 \leq x \leq 13 \\ \frac{18 - x}{5} & \text{se } 13 < x \leq 18 \end{cases} \]

- **FunzioneCrescitaAlta(15, 20, 30):**
  \[ y = \begin{cases} \frac{x - 15}{5} & \text{se } 15 \leq x \leq 20 \\ 1 & \text{se } 20 < x \leq 30 \end{cases} \]

\[ x \rightarrow \text{number of people added to the crowd in a minute} \]
Duration
Membership functions experimentally designed according to concerts background knowledge
Tabella 4.6: Calcolo dei parametri per le funzioni di durata.
Crowd profiling

- Quantitative/qualitative information to characterize crowd members, expected behavior, featuring dynamics
Classifying Crowds at Concerts: Case study at Lorenzo Cherubini 2008 Safari tour Brescia (I), December 13th, 2008

- Direct observation
- Scene analysis of acquired and available images/videos
- Knowledge engineering: Structured interviews (ref. To Elias Canetti framework) pre, post, and during the event
La folla al concerto del 13 dicembre è stata classificata come:

- folla chiusa;
- folla rapida.

Sono state individuate inoltre tre folle minori incluse nella folla generica presente al concerto:

- folla dei membri del Fan Club;
  - classificata come folla lenta;

- folla del pubblico sulle tribune;
  - classificata come folla chiusa e rapida (senza movimento);

- folla del pubblico sulla platea;
  - classificata come folla chiusa e rapida (con movimento).

I risultati sono stati illustrati utilizzando il tool OWL2Prefuse.
Classification of 13.12.2009 Safari concert Crowd

- Closed and rapid
- Component crowds and spatial distribution differences:
  - Fan club: slow crowd
  - Standing public: rapid crowd with movement
  - Seated public: rapid crowd without movement
• Knowledge sharing and information system for
  • collected data during real-world experimentations
  • analytic results for model comparison, calibration and set-up
  • software platforms nowadays available to study the dynamics of systems of pedestrians and crowds
• Collecting and analyzing information about self-organizing phenomena at stadium
Current/Future activities

• Formal and computational tools for the study crowds phenomenology and dynamics at pop-rock concerts
• Feasibility studies for decision support systems to design and manage public spaces and events
• Bottom-up computational approaches to study the behavior and dynamics of crowds as resulting from the behavior of huge numbers of individuals taking part to it (physical and emotional interactions)
• Crowds@FujiRock - Summer 2009 (with Aerospatial Institute Tokyo University)
Thank you!

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