Laboratoire en Innovation,
Technologie, Économie et Management

Une approche multi-agent basée sur la confiance pour évaluer la performance des plateformes de crowdsourcing d'idées

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Journées Francophones sur les Systèmes Multi-Agents (JFSMA)

Jeudi 06 Juillet 2017

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Context: Crowd Innovation

Existing research

- Model users and their relationships using a coopetition network [Hu et Zhang,2014] [Levine and Prietula, 2014]
- Focus on examining users' behavior (e.g., roles, motivation, . . .) [Bullinger et al.,2010] [Muhdi and Boutellier, 2011]
- Conduct exploratory analysis on static data derived using quantitative and qualitative methods [Hutter et al.,2011] [Fuller et al. 2014]

$\Rightarrow$ To improve idea generation quality

Limits

- ☹ Mono-relational model of the coopetition network
- ☹ Lack support for the social dimension (trust, interactional history, . . .)
- ☹ Little is known about the social dynamics of users and how their relationships may evolve in the platform

Our solution

To address these three limits, we propose:

- ☺ A multi-relational coopetition network model which takes into consideration cooperative, competitive and coopetitive relationships.
- ☺ A trust model as trust is considered as the main mechanism that enables agents to reason about the confidence of others and guides their decision-making process when they want to interact.
- ☺ An agent-based simulation as agents have demonstrated the ability to support interactions and their dynamics while using reasoning, extraction and representation of knowledge as well as social metaphors like trust.

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Concepts definition

Snapshot $G_i =< V, E_i, t_i >$

- $V = \{a_1, a_2, ..., a_n\}$ is a set of n agents;
- $E_i = \{E_{i,pos}, E_{i,neg}\}$ is a set of directed edges where $E_{i,I} \subseteq V \times V \, \forall I \in \{pos, neg\}$ is the set of edges w.r.t the interaction type;
- t_i is a time period.

Coopetition network $G_{[t_0,t_z]} =< V, E, W >$

- $V = \{a_1, a_2, ..., a_n\}$ is a set of n agents;
- $E = \{E_{coo}, E_{com}, E_{cop}\}$ is a set of directed edges where $E_I \subseteq V \times V \, \forall I \in \{coo, com, cop\}$ is the set of edges w.r.t the R_I relationship;
- $W : E \mapsto [0, 1]$ is a weight function mapping directed edges to their trust values;

Agent architecture

Selon Castelfranchi et al., 1998 :
"Only a cognitive agent can trust another agent".

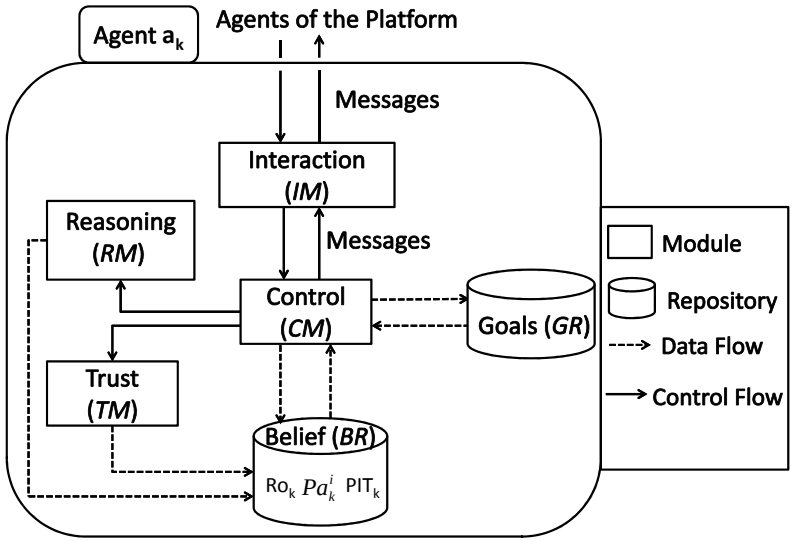

Figure: Architecture of a cognitive agent based on trust

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Trust model

Our trust model is composed of two dimensions:

- The environmental dimension: corresponds to **the perception** evaluated on the basis of information extracted from the coopetition network
  - Climatic trust
  - Social trust
- The dyadic dimension: represents **the confidence** of one in another and computed on the basis of their interactional history while taking into account the time-related aspect in the building process.

Climatic Trust

Observed Trend (Tr_i)

Let

- $G_{i-1} =< V, E_{i-1}, t_{i-1} >$ be a snapshot of time period t_{i-1}
- $Pset_i$ be the set of perceived actions randomly chosen from E_{i-1}

$Tr_i =< V', E' >$, is a sub-graph of G_{i-1} induced by $Pset$ such as $V' \subseteq V$ is a set of agents and $E' = E_{i-1} \cap V'$ is the set of directed edges between them

$$CTrust(a_k, Tr_i) = \frac{cardinal(\{ac^+ \in Pset_i\})}{cardinal(Pset_i)}$$

Social Trust

Egocentric Network

Let

- $G_{[t_0,t_i]}$ be a coopetition network graph
- $Z \in \mathbb{N}$ be the relative strength of memory

$H_{[t_i-Z,t_i]} =< V', E' >$ is a sub-graph of $G_{[t_i-Z,t_i]}$ centered on a_k such as

$V' = \{a_j \in V \,|\, (a_k, a_j) \in G_{[t_i-Z,t_i]}\} \cup \{a_k\}$ and E'$=\{ \bigcup_{x=i-S}^{i} E_x \cap a_k\}$

$$STrust(a_k, H_{[t_i-Z,t_i])} = \frac{cardinal(\{ac^+ \in E'\})}{cardinal(E')}$$

Environmental Dimension

Trust aggregation

$$ETrust(a_k, Tr_i \cup H_{[t_i - Z, t_i]})) = w \times CTrust(Tr_i) + (1-w) \times STrust(a_k, H_{[t_i - S, t_i]}))$$

The environmental trust value is used to qualify the perception

- ☞ $ETrust(a_k, Tr_i \cup H_{[t_i - Z, t_i]})) \in [0, \frac{1}{3}[\Rightarrow$ perceived impression= competition
- ☞ $ETrust(a_k, Tr_i \cup H_{[t_i - Z, t_i]})) \in [\frac{1}{3}, \frac{2}{3}] \Rightarrow$ perceived impression= coopetition
- ☞ $ETrust(a_k, Tr_i \cup H_{[t_i - Z, t_i]})) \in]\frac{2}{3}, 1] \Rightarrow$ perceived impression= cooperation

Dyadic Dimension

Temporal Jøsang's trust model

$$b = \frac{p}{p+n+1} \qquad d = \frac{n}{p+n+1} \qquad u = \frac{1}{p+n+1} \qquad b+d+u = 1$$

where:

$p = \sum_{l=0}^{l=i} (ac_{jl}^{+} * e^{-\frac{t_i - t_l}{Z}})$ is the number of positive actions

$n = \sum_{l=0}^{l=i} (ac_{jl}^{-} * e^{-\frac{t_i - t_l}{Z}})$ is the number of negative actions

Evaluation

$$DTrust(a_k, a_j, t_i) = \begin{cases} b & if \quad u < \theta \\ \begin{cases} T_s & \text{if } Ro_k = cooperator \\ T_w & \text{if } Ro_k = competitor \\ T_r & \text{if } Ro_k = coopetitor \end{cases} & otherwise \end{cases}$$

where θ is an uncertainty threshold reflecting the reliability of the trust evaluation

Relationship Characterization

Let

- λ_{inf} and λ_{sup} be respectively, the trust lower and the trust upper thresholds
- $DTrust(a_k, a_j, t_i)$ be the dyadic trust value that the agent a_k has in the agent a_j at time period t_i
- $\rho : E \mapsto R$ be a function that links directed edges to the relationships they represent

☞ $DTrust(a_k, a_j, t_i) \geq \lambda_{sup} \Rightarrow \rho((a_k, a_j)) = R_{coo}$

☞ $DTrust(a_k, a_j, t_i) \in]\lambda_{inf}, \lambda_{sup}[\Rightarrow \rho((a_k, a_j)) = R_{cop}$

☞ $DTrust(a_k, a_j, t_i) \leq \lambda_{inf} \Rightarrow \rho((a_k, a_j)) = R_{com}$

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Decision-making process

At each time period t_i of the simulation, every agent has to make the following decisions based on trust evaluation:

1. What is its potential for action ? (i.e number of actions to perform)
2. With who to interact ? (i.e. known or unknown agent)
3. How to interact with it ? (i.e. positive or negative action)

Potential for action (Pa_k^i)

Let $\mathcal{N}_k$ be he maximum number of possible actions that an agent a_k can perform at each time period t_i

Role of agent a_k \ Qualified perception	competition	coopetition	cooperation
competitor	high Pa_k^i ($\mathcal{N}_k$)	medium Pa_k^i ($\frac{\mathcal{N}_k}{2}$)	low Pa_k^i ($\frac{\mathcal{N}_k}{4}$)
coopetitor	medium Pa_k^i ($\frac{\mathcal{N}_k}{2}$)	high Pa_k^i ($\mathcal{N}_k$)	medium Pa_k^i ($\frac{\mathcal{N}_k}{2}$)
cooperator	low Pa_k^i ($\frac{\mathcal{N}_k}{4}$)	medium Pa_k^i ($\frac{\mathcal{N}_k}{2}$)	high Pa_k^i ($\mathcal{N}_k$)

Table: Potential for action of an agent a_k according to the qualified perception and its role

With who to interact

Agents evolve in crowd innovation environment

$\Rightarrow$ Agent a_k interacts with:

- Known agents $LKA_k \subset PIT_k$ such as $|LKA_k| = \alpha * Pa_k^i$
  - cooperator: top trustworthy agents
  - competitor: least trustworthy agents
  - coopetitor: no matter
- Unknown agents $LUA_k \subset V \setminus \{PIT_k\}$ such as $|LUA_k| = (1 - \alpha) * Pa_k^i$

Action rules

Role of a_k \ Action type	probability of positive action	probability of negative action
cooperator	p^+=1	$p^- = 0$
competitor	p^+=0	$p^- = 1$
co-opetitor	$p^+ = ETrust$	$p^- = 1 - ETrust$

Table: Actions rules between an agent a_k and an unknown agent $a_j \in LUA_k$

Relationship between a_k and a_j / Role of a_k	R_{com}	R_{cop}	R_{coo}
competitor	$p^+ = 0,\ p^- = 1$	$p^+ = DTrust,\ p^- = 1 - DTrust$	
cooperator	$p^+ = DTrust,\ p^- = 1 - DTrust$		$p^+ = 1,\ p^- = 0$
co-opetitor	$p^+ = 0,\ p^- = 1$	$p^+ = DTrust,\ p^- = 1 - DTrust$	$p^+ = 1,\ p^- = 0$

Table: Trust-dependent actions rules between an agent a_k and a known agent $a_j \in LKA_k$ for the different relationship types

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Experimental setup

- $n = 1000$
- $\mathcal{N}_k = 4$
- $\alpha = 0.5$
- $cardinal(Pset_i) = \frac{cardinal(E_{i-1})}{10}$
- $Z = 5$
- $\lambda_{inf} = 0.3$ and $\lambda_{sup} = 0.7$
- Simulation duration: 50 time periods
- Roles distribution: homogeneous $\Rightarrow$ 33% of cooperators (C_{coo}), 33% of competitors (C_{com}) and 33% of coopetitors (C_{cop})
- $performance_i(C_l) = \frac{|\{a_k \in C_l \mid Pa_k^i > \frac{\mathcal{N}_k}{2}\}|}{|C_l|} \forall l \in \{coo, com, cop\}$

Results

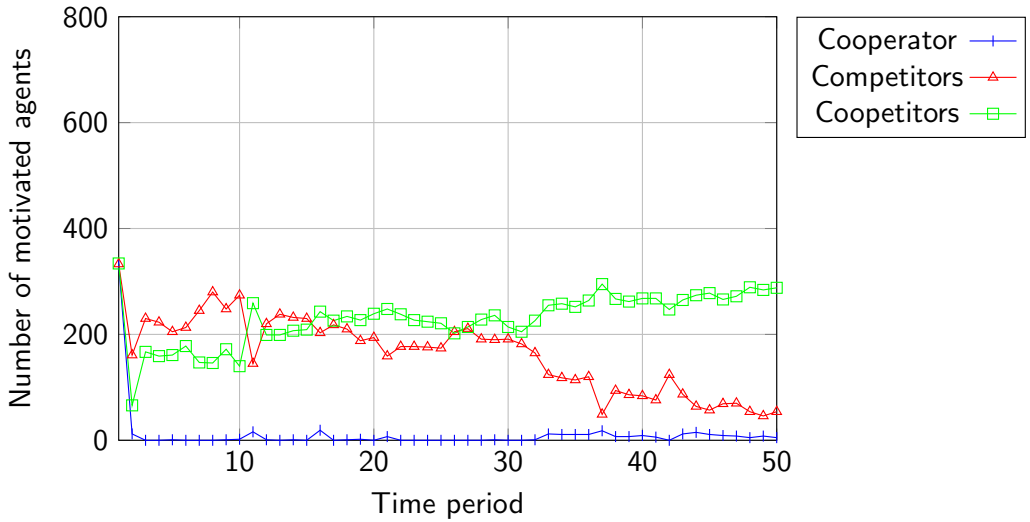

Figure: The performance evolution in an homogeneous platform

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Conclusion

- A multi-relational social network model
- Trust management model built upon two dimensions: environmental and dyadic to guide decision-making process of agents when they interact
- An agent-based model to simulate users' behavior and understand social dynamics in homogeneous platform

Future Research

- Study new and not deterministic action rules
- Examine a dynamic roles distribution where individuals can change roles
- Perform an exploratory and structural analysis of obtained graphs
- Make more simulations while varying the parameters values.

Merci !
Questions ... ?