ODD + D documentation for the simulation model: an agent-based social simulation for citizenship competences

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Simulating conflict resolution with citizenship competences

In order to have an standard for documenting ABMs, (Grimm et al., 2006) proposed the Overview, Design concepts, and Details (ODD) protocol, first published as a standard for the description of individual and ABMs and updated in 2010 (Grimm et al., 2010). However, (Müller et al., 2013) proposed an extension to this protocol as the ODD + D which includes elements for describing human decisions.

The Agent-Based Social Simulation for Citizenship Competences (ABSSCC) was implemented in NetLogo 6.1.1. The ABSSCC is described by using the ODD + D protocol (Müller et al., 2013).

2.1. Overview

- **Purpose**

The purpose of the ABSSCC model is to understand how citizenship competences influence in the conflicts' resolution. In this model people interact in zones where they should solve conflicts and a conflict is solved considering two cases: when there is the presence of citizenship competences and when not. In both cases the solution of a conflict depends also on the TKI level which is selected randomly. The simulation was designed taking into account the citizenship competences model proposed by (Chaux et al., 2004) and the TKI conflict resolution styles (Thomas & Kilmann, 1974, 2008). The competences model was implemented into an RDF (Resource Description Framework) ontology. A NetLogo extension was developed in order to retrieve information from the ontology. Figure 1 depicts an excerpt of the ontology which is described as follows: there are two conflicts (conf_st_10 and conf_st_1) that belong to the street zone (esce_Street). Each of the conflicts has associated a specific competence. For instance, the conf_st_10 has the competence of conflict management which is under the integrative category according to the competence model adopted.

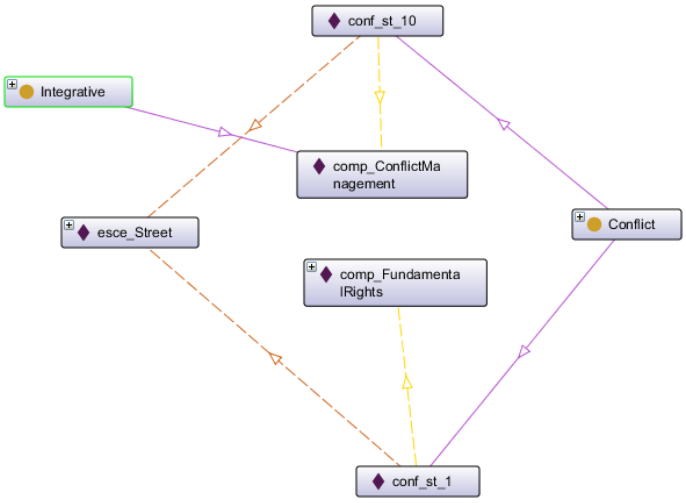

Figure 1. Excerpt of the ontology for citizenship competences

- **Entities, state variables and scales**

The model has only one type of breed (citizens). The simulation scenario consists of four zones: work, home, street, and a social marketing area which refers to those places with advertisements or information about things like taking care of a place or throwing litter in the right place, among others. The scenario should have at least two people so that they can interact in the resolution of conflicts in each zone. In addition, a competence is associated with each conflict and each time two people interact in the resolution of a conflict, the level of competencies for each citizen is specified. Initially, this level is defined randomly and then is updated each time the citizen interacts in a new conflict. In the simulation there is a switch that allows to determine if the simulation will run considering OR not the citizenship competences. When that switch is off, conflicts are solved in a random manner otherwise, a conflict is solved taking into account the level of competence of each of the citizens who interact in that conflict.

The simulation space, which in NetLogo is known as the “world”, is a space with a total of 1600 plots divided into a 40 by 40 frame. The origin is settled in the left-down square as shown in Figure 2. This world in turn is divided by 4 zones of equal size, each zone is identified with a different color and represents the zones mentioned above. Within each of these zones, a maximum of 10 conflicts are defined, each conflict is represented in the world by a set of 9 patches. Each unit in time is represented by a tick which is in turn each step that is performed in the system.

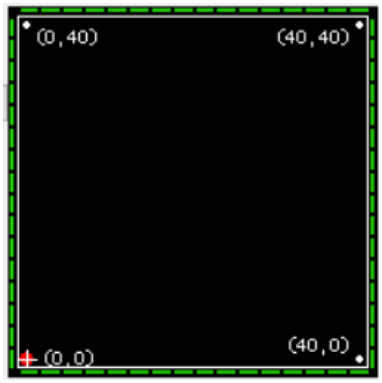

Figure 2. Simulation world's coordinates frame

The scenario also includes a set of variables that allow to store information about the simulation through the time (ticks) and that are also used to store the information in a comma separated file by using the csv extension.

One of the variables defined for the scenario is a scale by which you can configure the number of citizens that will be added to the simulation space. This scale ranges from 10 to 500. There is also a parameter that allows defining the amount of ticks that the simulation will last. Table 1 shows the values that the parameters and variables involved in this model can take.

Regarding the output information, there are information boxes that show the conflicts that have been solved and the total conflicts in which each area has been interacted. In addition, three graphs are presented, one that allows the comparison of solved conflicts versus not-solved conflicts over time, a second graph that represents the behavior of the general competence level of the simulation system and a final graph that represents the presence of people for each of the zones.

Table 1. Variables of the simulation model

Type	Variable	Default value	Minimum value	Maximum value
Slider	numberOfCitizens	10	10	148
Switch	withCompetences	Off	Off	On
Entry	ticksNumber	150	0	-
Global	conflicstList	0	item 0	item 40
Global	competenceLevel	0	0	10
Global	zoneName	0	one-of ["Work" "Home" "Street" "SocialMarketing"]	one-of ["Work" "Home" "Street" "SocialMarketing"]
Global	turtlesToEvaluate	0	one turtle	n turtles
Global	solved	0	0	n conflicts solved
Global	notSolved	0	0	n conflicts not solved
Global	TKI styles (avoiding competing accommodating collaborating compromising)	0	1	5
Global	confSol (Work, Home, Street, SocialM	0	0	n conflicts solved according to the zone

Global	totalConf (Work, Home, Street, SocialM)	0	0	total conflicts according to the zone
Global	peopleAt (Work, Home, Street, SocialM)	0	0	Sum of citizens that passed by the zone
Global	csvData	0	item 0	item n
turtles-own	individualCompetences	0	item 0	item n

- **Process overview and scheduling**

The simulation runs under two possible cases according to defined model: a case where citizenship competences are used for conflict resolution and another case where the competences are not considered. For the first case, the model analyzes the level of competencies of each of the agents that interact in a conflict and a TKI style is selected to determine wheter the conflict is solved or not. Therefore, it is determined that a conflict has been solved if either of the two agents present in the conflict has a level of competence greater than or equal to 5. Each time a conflict is solved, the level of competence of each agent increases by one unit. In turn, the calculation of the general level of competencies is taken into account in order to contrast it with the conflicts that have been solved.

At each step the following instructions for citizens are taken into account:

a. All citizens in the scenario move randomly.
b. For each citizen present in the simulation scenario.
    a. The name of the zone is defined.
    b. According to the zone, a unit is added to the variable that counts the number of citizens of the respective zone.
c. The color of the plot is identified for the citizen currently being evaluated.
d. According to the color of the plot, the neighbors who are in the same conflict are identified.
e. The resolution of the conflict begins whenever there are two citizens present.
f. If the simulation is running without considering the competences, the conflict is solved in a random way and considering the TKI style selected.
g. If citizen competencies are being considered, for each citizen one must ask if they already have the competence associated with the current conflict or if it is necessary to add it. Each time a new competence is added, the list of individual competencies of a citizen, the level of competence is determined through a random number ranging from 1 to 10. If the competition already exists in the individual list of competencies, it is not necessary to retrieve its current level value.
    a. If the level of competence of any of the two agents is greater than or equal to 5, it is considered that the conflict can be solved or not according to the TKI style selected and, in the case the conflict would be solved the level of competence of each of the citizens present in the conflict is increased.

2.2. Design concepts

- **Theoretical and empirical background**

The citizenship competences development has been fostered by national and international entities with a special focus on citizenship education, which is a social component that influences the development of political regulations and decision-making processes. To understand the dynamics of a social system which involves citizens acting with citizenship competences has not been addressed from the use of computational techniques which would contribute to an approximation about the dynamic of the social system in experiences such as the conflicts resolution. Social systems are complex systems with real world entities and their behaviors and relationships. Thus, the model uses an ontology developed as a representation of the citizenship competences domain and, to simulate a case study involving the use of the ontology. To do so, it was identified that the use of the ontological engineering allows the modeling of knowledge domains and that combining it with other areas such as agent-based social simulation allow to describe the dynamics of a social system.

Agent-Based Social Simulation (ABSS) is based on the concept of computer simulation, which is defined as the representation of something (Starbuck, 1983) and has been adopted in a wide range of topics such as climate (Ziervogel et al., 2005), natural disasters (Mustapha et al., 2013), transportation (Hager et al., 2015; Tchappi Haman et al., 2017), and food (Zia et al., 2018), among others. In the human behavior field, computer simulation seeks to represent people's behavior, however it does not mean that the simulation must look exactly like the real world (Dutton & Starbuck, 1971). This is because of the complexity of social systems and the wide number of variables that are involved in cases in which the observation is based primarily on human behavior (Müller et al., 2013).

- **Individual decision making**

A conflict resolution depends on the competence level of both citizens interacting in, and the a conflict resolution style which is based on the TKI model (Thomas & Kilmann, 1974, 2008). The possible values for the TKI are:

  - 1 = Avoiding: when the person ignores the conflict.
  - 2 = Competing: only one person wants to be the winner.
  - 3 = Accommodating: one person gives into the demands of the other.
  - 4 = Collaborating: both co-create a shared solution.
  - 5 = Compromising: both give an acceptable solution.

As mentioned before, in the simulation scenario, there is a variable to determine whether the citizenship competences are considered or not. Rules for both cases are described as follows:

- Case 1: withCompetences = true
  - TKI = 1: if the competence level of both citizens has risen a higher level (8 or more) the conflict is solved, otherwise the conflict is not solved.

    - TKI = 2: one of the citizens is selected randomly, if the winner has a competence level greater than the other the conflict is solved, otherwise the conflict is not solved.
    - TKI = 3: as one of the citizens should give into the demands of the other, the conflict is solved.
    - TKI = 4: if the competence level of both citizens is equal or greater than 5, the conflict is solved, otherwise the conflict is not solved.
    - TKI = 5: the acceptable solution is defined as to have a competence level between 3 and 6 (both included). If both agents meet such requirement, the conflict is solved. Moreover, if the competence level of both citizens has risen a higher level (8 or more) the conflict is solved, otherwise the conflict is not solved.
- Case 2: withCompetences = false
    - TKI = 1: the conflict is not solved.
    - TKI = 2: the conflict is solved is a random value between 1 and 2 is 2, otherwise the conflict is not solved.
    - TKI = 3: two random values from 1 to 10 are selected. Then a number between 1 and 2 is selected randomly and this correspond to one of the previously selected values. If the value of the winner is greater than the value of the other, then the conflict is solved, otherwise the conflict is not solved.
    - TKI = 4: two random values from 1 to 2 are selected. If both values are the same, the conflict is solved, otherwise the conflict is not solved.
    - TKI = 5: a random value from 1 to 10 is selected. If the value is between 3 and 6 (both included), the conflict is solved, otherwise the conflict is not solved.

- **Learning**

In this model de decision-process depends on the level of competences and the actions the citizens take. The level of competence of each citizen interacting in a conflict influences the way he/she acts when interacting in a conflict.

- **Interaction**

One citizen interacts with another citizen in the sense they move randomly and meet each other in a conflict. Interactions are thus consequence of two citizens meeting in a conflict that is identified by its patch color (pcolor) in the simulation scenario.

- **Collectives**

Citizens interact in pairs in a specific conflict resolution. In this case, as each conflict consist of a set of 9 patches with a unique color. A conflict resolution is activated if there are two citizens with the same patch color and if that color is included in the conflicts list.

- **Heterogeneity**

The citizens' decision-making process is influenced by the action each one takes when solving a conflict. Thus, there is no heterogeneity among the agents in the decision-making.

Considering or not the citizen competences in this simulation scenario allows observing the dynamics in the resolution of conflicts and the general competences level. Moreover, to solve or not a conflict also depends on the TKI style of each person. Thus, when there are no enough variables it is not an easy task to predict whether a conflict is resolved or not.

- **Stochasticity**

The individual level of competence, the TKI style to select and, the decision of solving or not a conflict when the citizenship competences are not considered, are modelled randomly.

Stochasticity is present both in the movement of citizens and in the resolution of conflicts when citizen competencies are not considered. This is because it is not easier to predict either the places where a person can live in their daily lives or the exact competence level they have. With a small number of citizens, it is hard to really observe what is happening with the competences level and the conflict resolution. Therefore, it is recommended to use a high level of citizens present on the simulation scenario. From a certain point of the time (tick) it would be possible to observed in the mean of the level of competences reaches a maximum point and the dynamics of resolved and unresolved conflicts tend to be constant. To verify this number of ticks can be varied in the scenario.

2.3. Details

Figure 3 depicts the components used for developing the simulation scenario. There is an ontology that was developed to present the citizenship competences and the conflicts to set in the simulation scenario. The ontology was developed using the Protégé software (Standford, 2017). Besides that, three NetLogo extensions were included:

- ontoquery: developed in Java and the NetLogo 6.1. API. This extension allows to make queries over the ontology by using the JENA's API, which is a semantic web framework for Java.
- array: an extension included in NetLogo in order to manage arrays.
- csv: an extension included in NetLogo used to export data from the simulation.

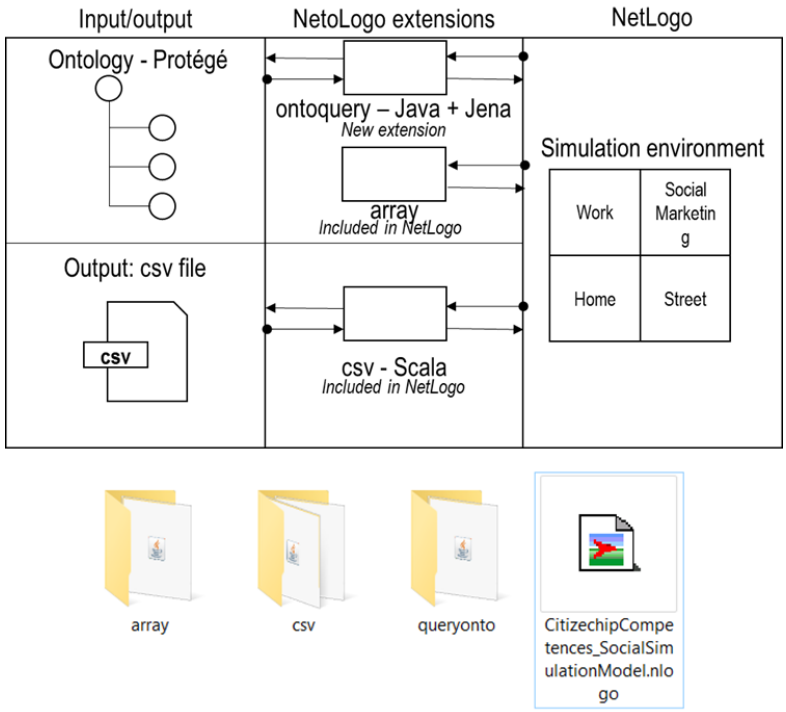

Figure 3. Components of the simulation scenario

- **Initialization**

Regarding the initialization of the scenario, there is a breed named “citizens”. Citizens are randomly placed on a zone and their individual list of competences is initially empty. To do this, it is possible to determine the number of citizens who will be present in the simulation by selecting a number on the citizens number scale. It is also possible to define whether to consider or not the use of the citizenship competencies through the switch included for this purpose in the simulation scenario. The scenario also includes an input for defining the number of ticks. Once these variables have been defined, the “Setup” button is used to locate the necessary elements in the simulation scenario.

Once the setup has been initiated, the each of the four zones receive a zone name and at most ten conflicts are added per zone. Each conflict is added to a list of conflict defined as a global variable. Such list contains both the zone name and the competences associated. At this point the ontology is queried by using the ontoquery extension which receives the zone name and the current list of conflicts as depicted in Figure 4.

```
let competences array:from-list queryonto:ontology zone conflictsList
```

Figure 4. Example for using the ontoquery extension

Then the “Go” button allows to start the simulation and it will stop until the number of ticks defined is reached. Finally, the Restart button can be used to clear the stage and re-initialize the variables. Figure 5 depicts the initial conditions of the simulation.

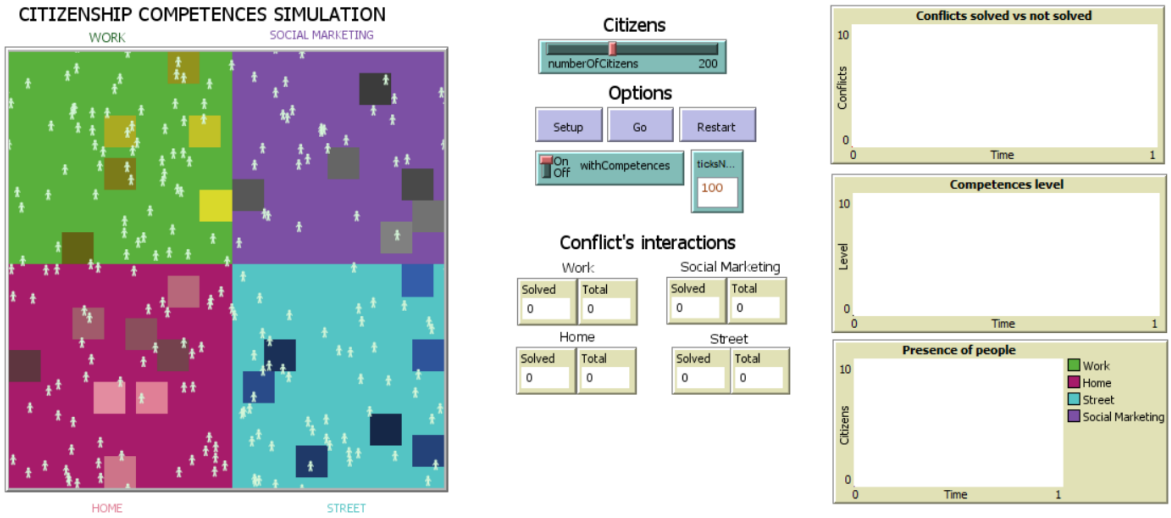

Figure 5. Initialization of the simulation scenario

- **Entries**

Entries for the simulation scenario are the number of citizens ranging from 10 to 500, the conflicts settled in the scenario (at most ten per zone), the number of ticks, and de decision on running the simulation with or without the citizenship competences.

- **Sub models**

The sub models that integrate this scenario for the ABSSCC are: definition of the name of the zone, obtaining a conflict, verification of the existence of a conflict, adding conflicts to the list of conflicts on the stage through a consultation ontology, conflict resolution based on the level of competencies and the TKI styles, conflict resolution based on a random number and the TKI styles.

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