An Axiomatic Study of Reputation Systems
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Since the advent of Internet, many multi-agent systems of large size have been developed, in particular in the field of e-commerce. In these systems, the user faces a large number of agents which it does not know, yet it has to choose those with which it will interact. Clearly, the user needs some help to make a good choice, in particular, it needs some indication of which agents are the best, which should be avoided, etc. Take for example Ebay, it is crucial for buyers to have some indication of which sellers are reliable and which failed to fulfill their commitments. Another important example is that of web pages. There are so many of them that it is necessary for surfers to have at their disposal tools which help them to choose the good ones.

To answer this type of need, reputation systems have been developed. Such a system is composed, first, of a set of agents which provide information about their peers, and second, of a method which constructs a ranking of the agents from this information. This ranking represents in some sense their different reputations. For example, Ebay is equipped with a system which collects the grades buyers and sellers give to each other, and which attributes a score to each ebayer on the basis of these grades. Concerning web pages, a reputation system is formed if a search engine like Google is added. Indeed, Google interprets a link between two pages as a recommendation of the source in favor of the target, and provides a ranking on the basis of these recommendations.

The goal of the present project is to make an axiomatic study of reputation systems. Such a study would allow us to judge and classify existing solutions, and of course to provide new systems. In fact, the aim is to analyze reputation systems in the same way voting systems have been in Social Choice. A voting system is composed, first, of a set of voters and a typically disjoint set of alternatives, and second, of a method which ranks these alternatives on the basis of the preferences the voters express about them. The main difference is that with reputation systems, the alternatives are the voters themselves, which allows new considerations to appear and to influence the development on these systems.

As far as we know, this avenue of research was first explored by M. Tennenholtz in [Ten04]. That paper was followed by several others written in collaboration with A. Altman [AT05a, AT05b, AT06, AT07]. The present project would therefore reinforce the exploration of a new avenue of research which has yet proved to be fertile. The main part of the work can be divided into 5 tasks:

- The first task consists in developing a formal environment in which agents provide information about their peers. A simple example is a graph, the nodes represent agents and the arrows represent recommendations of the sources in favor of the targets. Even though this model is extremely simple, it is sufficient to represent a real environment as important as that of web pages.

- Once an environment has been specified, the second task consists in establishing properties which should be satisfied by ranking methods. An important point is that these properties should be intuitive and desirable, this is the reason why they are called axioms. It is especially
at this point that the differences between reputation systems and voting systems will appear. Indeed, since the agents are themselves the objects of the votes, and therefore the objects to be ranked, properties which make no sense in Social Choice will emerge and get importance. A good example is Transitivity, it says that if a method ranks the supporters of an agent $a$ (that is, the nodes which send an arrow to $a$) higher than those of an agent $b$, then it should rank $a$ higher than $b$.

- The next step consists in devising ranking methods which satisfy as many axioms as possible. These methods may be complex, but it is important that we have a rough intuition that they act well. Next, the axioms will allow us to judge and compare them in a precise way. The more a method satisfies axioms (and the more these axioms are desirable), the more the method is justified from a theoretical point of view. The ideal would be to have enough axioms to completely characterize it, that is, to have a set of axioms that the method is the only one to satisfy. In that case, we would in some sense know all the properties enjoyed by the method, and therefore we would be able to judge it with even more precision. This kind of result, called representation theorem, is generally hard to obtain.

- Another benefit of the previous task is that it allows us to develop further the axiomatic classification of ranking methods. More precisely, it provides full or partial answers to essential questions like: given a set of axioms, which are the methods which satisfy it? The goal the fourth task is to answer systematically this type of question. In other words, the aim is to take a set of axioms and to look for as many methods enjoying it as possible. Once again, the difficulty will be to find them all, which would establish again a representation theorem.

- Another kind of answer may be provided to the questions of the previous task. Indeed, one may on the contrary show that, for a given set of axioms, there does not exist a method which enjoys it. This would constitute an impossibility theorem which has the advantage of showing the limits of what can be done. However, the ideal would be to find also, for each strict subset of axioms, a method which satisfies it. In this way, one would show that what poses a problem is definitely the whole set, and not just a part of it.

Finally, once we have developed new reputation systems and provided theoretical justifications for them, we will test them in practice. More precisely, we will implement them in a simulation, where they will compete against other systems. An example is the ART (Agent Reputation and Trust) testbed. In this simulation, there is a set of appraisers which can provide information about their peers. Each appraiser has to evaluate a set of paintings. If an appraiser does not have enough expertise in some kind of painting, it can ask other appraisers for their opinions. Of course, the difficulty is to choose the good ones, which is the task of the competing reputation systems. The appraiser equipped with the best system is in principle the one which will make the best evaluations, and therefore the one which will win the game.

To summarize, the goal of the present project is to make an axiomatic study of reputation systems, and to supplement this study with experimental tests.
References


