Computational Models of Attention Competition

Agent Based Models for Attention Scarcity

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Abstract

Attention scarcity is a natural consequence of huge amount of information. In the new digital age, information has grown increasingly abundant and immediately available. Thus it is easy to see that the scarcest resource of today is not information but rather attention. In this study, we will be working on computational models of attention competition. We will design several complex adaptive social systems in which agents with limited attention capacity, confront a wealth of information. Agents must pay attention to what they are paying attention to, in order to achieve a higher social welfare. We think that an analysis of how agents selectively attend to information will provide interesting scientific opportunities.

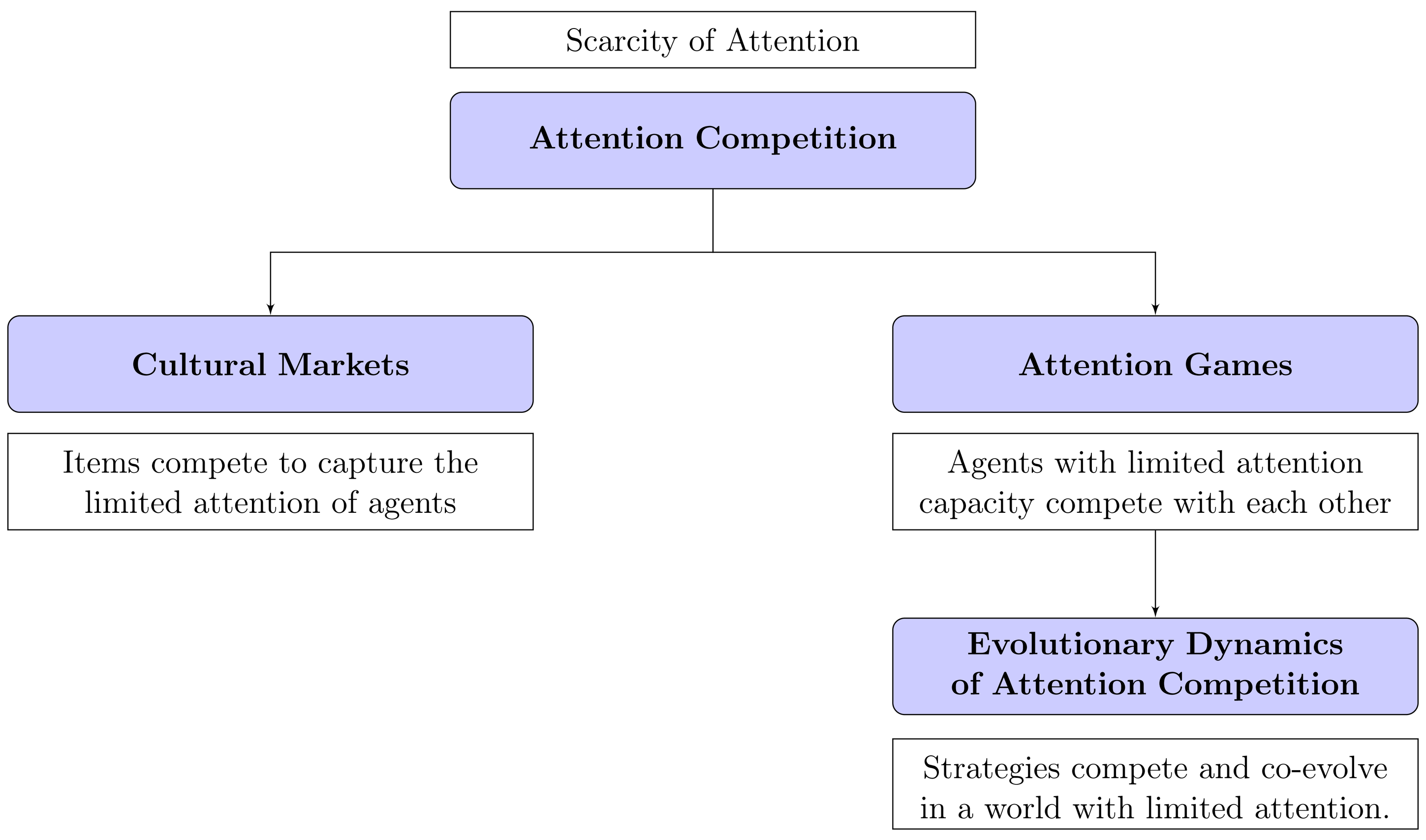

Figure 1: Computational Models of Attention Competition

We have investigated attention competition from different view points, as seen in Fig. 1. First, we worked on cultural markets where items compete for the limited attention of agents [2]. Second, we worked on games where agents with limited attention capacity compete with each other [3]. As a future work, we plan to investigate evolutionary dynamics of attention competition. In this case, strategies will compete and co-evolve in a world with limited attention.

Cultural Markets

In a cultural market, it is assumed to have an infinite supply for cultural products. Abundance of immediately available products can easily exceed customers capacity to consume them. Attention scarcity due to the vast amount of immediately available products is also the case for cultural markets. Cultural products, like memes or any other units of information, compete for a share of our minds to gain a broader popularity.

Simple Recommendation Model (SRM) [1] investigates how individuals become popular among agents with limited memory size. In SRM, the spread of information through out the system, is managed by only recommendation. We extend SRM to Attention Competition with Advertisement (SRMwA) [2]. In SRMwA, agents recommend items rather than agents. In addition to recommendation, advertisement pressure as new dynamic is introduced. As a result there exists two different type of items: *standard* and *advertised* items. Our research question is as follows: Which way of information spread is more successful, recommendation or advertisement? Is there any method to promote advertised item, without increasing the advertisement pressure?

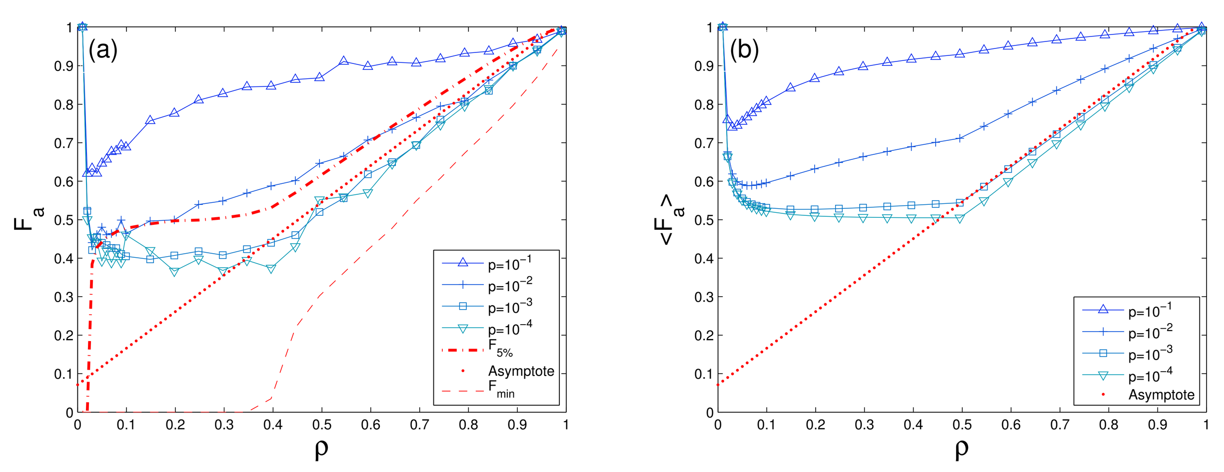

Figure 2: The market share of advertised item as a function of attention capacity ratio by (a) simulation and (b) analytic approaches. Let $F_{5\%}$ denote the lowest market share for an item to be in the top 5 percent. Then, the advertised item is in the top 5 percent whenever $F_a > F_{5\%}$. Let F_{min} be the minimum market share among all the items. $F_{5\%}$, F_{min} and the asymptote line of ref [1] are given for comparison.

System allows for both recommendation and advertisement simultaneously, taker agent should select one of them. Advertisement pressure is modeled by parameter p, which is the succeeding probability of advertisement. Therefore, $1-p$ is the succeeding probability of recommendation. A *giver* agent g recommends an item, that she already owns, to an individual. The item and the individual are called the *recommended* r and the *taker* t, respectively. The taker pays attention to, that is, *purchases*, either the recommended or the advertised item. When the attention capacity becomes exhausted, in order to get space for the purchased item, an item f that is already owned by the taker is *discarded*. The *market share* of an item is defined to be the ratio of population that owns the item.

The model is investigated analytically and by simulation. Specifically, the transmission of information about an item within a population is treated as if it were the transmission of an infectious disease. An agent is called *infected* iff it has the advertised item in his memory. It is called *susceptible* iff it does not. Using the SIS model of epidemics, the system can be modeled as a Markov chain. Consider a population of N agents. Let S_i be the state in which the number of infected agents is i. The state space is composed of $N+1$ states, $\{S_0, S_1, \ldots, S_N\}$ with S_0 and S_N being the reflecting boundaries. Then the stationary distribution π provides the probability of the number of agents owning the advertised item when the system operates infinitely long durations. Hence, the mean value of the stationary distribution π reveals our prediction for the number of infected agents (agents that adopted the advertised item).

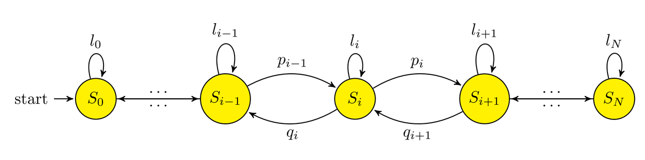

Figure 3: Markov Chain where states sharacterized by the number of infected agents.

Results

We have investigated the impact of advertisement pressure on a cultural market where consumers have a limited attention capacity. The analytical results agree with the simulations. We have observed that (i) Advertisement is found to be much more effective when attention capacity of agents is extremely scarce.. When individuals have a limited attention capacity, they tend to adopt what is promoted globally rather than what is recommended locally. (ii) The market share of the advertised item improves, even if the avertisement pressure is kept constant, while the number of items is increased by introducing dummy items.

Attention Games

Attention game defines an interacting environment where players can only pay attention to a portion of the information they recieve. The essence of any game is to interact with others and get a chance to improve the payoff one gets. To interact with others, one should first capture their attention in a positive manner. Little work has been done on games with limited attention. Our research question is turned out to be: How attention scarcity effects the outcomes of a game? We work on attention games in a specific context of Iterated Prisoners Dilemma. Despite its level of abstraction, Prisoners Dilemma game represents a very important question: For two rational agents, is it better for them to cooperate or defect? In our article of [3], we used a very simplistic model. We consider that there exist two type of players: cooperators, who always cooperate, and defectors, who always defect. We combine these pure strategies with a simple choice-and-refusal rule. If a player knows that the opponent is a defector, then he or she refuses to play. Otherwise he or she plays. This rule is a social norm related to the direct reciprocity.

Attention must be selective in order to decide which information is worth keeping in the memory. We defined this process as an attention allocation strategy. And we make a comparison of 5 simple attention allocation strategies : (i) *FOC*: Players that prefer to forget only cooperators. (ii) *FOD*: Players that prefer to forget only defectors. (iii) *FAR*: When players have no preference. (iv) *FEQ*: Players may also prefer to use coin flips to decide which type of player to forget. (iv) *FMJ*: One possibly effective strategy could be to assume the opponent be of the type of majority, hence, pay attention to the minorities only.

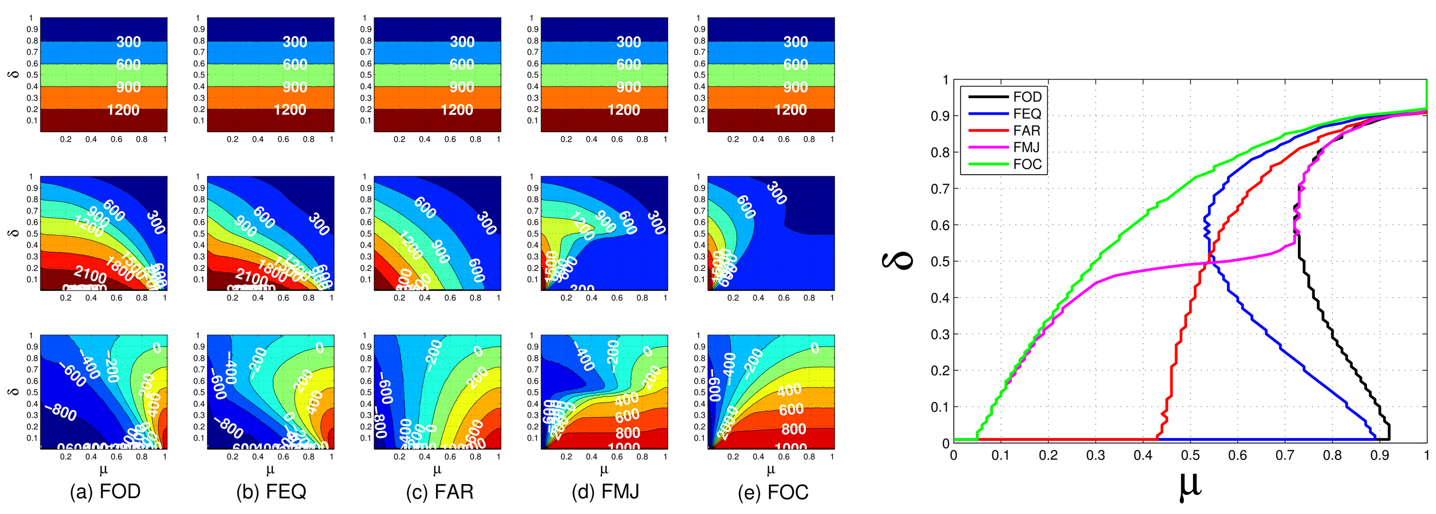

Figure 4: (Left Figure) Average performances as a function of attention capacity ratio μ and defector ratio δ. The columns represent five strategies. The rows represent $\bar{P}_C$ average performances of cooperators, $\bar{P}_D$ average performances of defectors and $\bar{P}_C - \bar{P}_D$ values, respectively. (Right Figure) X-axis of the figure represents the attention capacity ratio μ and Y-axis represents δ, the defector ratio of the population. The area under the curve of *attention boundaries*, where $\bar{P}_C - \bar{P}_D = 0$, represents the conditions in which cooperation is the favorable action.

Social welfare can be measured by the average payoff of players. An attention boundary determines the favorable action by comparing the average performances of the two types: cooperators and defectors. If a pair of (μ, δ) remains inside the attention boundary, it means that the cooperation is the favorable action, otherwise defection is the favorable action. Attention boundaries for five different attention allocation strategies can be seen in Fig. 4.

Results

We observe that as the proportion of the defectors increases, the average payoff for any player decreases. As attention capacity increases, the detection of the defectors gets feasible, consequently defectors face with social isolation due to the rule of choice-and-refusal. As a result, cooperators performance, exceeds the defectors performance. Thus, cooperation becomes the favorable action. We also find out that the best strategy is "forgetting only cooperators". To our conclusion, attention must be selective, and it should be directed towards the defectors and their defective moves. We can think that there is entity between cooperators and defectors. By applying this strategy, cooperators becomes more prudent to the defectors and their defective actions. We can conclude that it is crucial for attention to be focused on potentially threatening information.

References

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