The spread of misinformation

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Abstract

How does information behave? A recent controversial approach is to use ideas in evolutionary biology to study the spread of information. However, in order for the information to 'evolve', there has to be some mechanism for variation. This paper would explore the ideas of memes which use the evolutionary biology approach as well as the pitfalls in using this picture. Finally, we will focus our attention on the fidelity of information which affects the variation of memes. A multi-agent model[10] was used to study the effects of misperception and miscommunication in a simple resource gathering simulation.

1 Introduction

In order to study information, it is useful to define what it actually is. There are many ways to define it (Shannon's Entropy, Fisher's Information etc.) The definition that will be used comes from the field of memetics. Richard Dawkins refer to memes as a unit of information that spread from mind to mind[1][2]. In many ways, the emergent behaviour of memes is very similar to a biological virus. They have the following similar properties.

1. Replication.
2. Variation.
3. Natural Selection.

In order for an idea to spread, it must be able to make copies of itself, there are two main ways of doing so–imitation and language. However the

Figure 1: 'Kilroy was here' meme object on the WWII memorial in Washington D.C.[3], on TV[5], in a video game [5] and on a sign in Las Vegas[5].Notice the meme object comes in two variations. One is of a man peering over a wall, the other is of the phrase 'Kilroy was here'.

mechanism for reproduction is not perfect and this may lead to a variation in the memes. Such variation is due to recombination and mutation. When there is variation, some ideas would be 'fitter' than others leading to the process of natural selection.

Memes do exist in the real world. Popular cited examples include catch phrases, religion and fashion fads. One particularly interesting meme is the 'Kilroy was here'[3][4] graffiti meme. No one really knows the exact origin of the meme but the doodling of a man peeking over a wall was found all over Europe and the Pacific during the Second World War;possibly spread by US servicemen[3]. The fad ended around the 1950s but can still occasionally be seen in some places.

2 Difference between Memes and Biology

While it is very tempting to compare the behaviour of memes to biological systems. There are however some difficulties in taking the biological analogy too far.

1. Definition of an irreducible unit of information.
2. Replicator vs Phenotype.
3. Darwinian vs Lamarckian mechanism.

2.1 Definition of an irreducible unit of information

In biological systems, whether we are talking about a virus or an elephant, there is always a well defined set of definitions to follow. We pick the appropriate scale and level of complexity and apply it to the definition. Memes face this problem, because as complex representation of information, there are ambiguities in choosing the appropriate level of complexity to describe them. Technology is a good example of such a problem. For example, does one describe the idea of a car in terms of its function as a form of transportation or in terms of its internal mechanical parts. Furthermore, when an idea is passed from one individual to another, not all the exact details is transmitted and there may be no exact replication of thought in the receiver. What is transmitted is actually some abstraction of an idea.[6] This abstraction is common in both the minds of the sender and receiver and could be defined as the meme. While this approach is a step in the right direction to define memes, it is sometimes difficult to really agree on what the abstraction of an idea really is.

2.2 Replicator vs Phenotype [7]

In genetics, we have the genotype(replicator) and phenotype. The genotype is the information that can be transferred while the phenotype is the physical manifestation of the genotype(colour of eyes etc). Dawkins tries to clarify this distinction "between the meme itself, as replicator,on the one hand, and its 'phenotypes effects' or 'meme products' on the other."[1] He goes on to say that "A meme should be regarded as a unit of information residing in a brain."'[1] The problem with this distinction is that the phenotype may

play an important role in the replication process in some cases. If members of a primitive tribe saw the use of bows and arrows by a neighbouring tribe, they could acquire the meme for such technology through imitation and observation[9]. While inheritance in biological systems are due to genes, inheritance of ideas are due to the phenotype.

2.3 Darwinian vs Lamarckian mechanism [7]

Lamarck[8] theorise that organisms acquire genetic changes throughout its lifetime and these changes are passed on to its offspring. An often mentioned example is the view that a blacksmith's son will inherit the developed armed muscles that the blacksmith developed through the course of his occupation. This theory has largely been rejected by evolutionary biologist and can easily be falsified–a man who lost his legs through an accident will not go on to father leg-less offsprings. An idea may acquire variations during its lifetime without a need for replication. The acquired changes can be passed on to descendant ideas when the idea is copied. This may be called 'Lamarckian' in a sense. In contrast, a biological organism acquires variations due to the replication process; either through error(in the case of mutation) or recombination(in the case of sexual reproduction).

3 Misperception and the fidelity of information [10]

Short of telepathy, it is impossible to study the 'variation' of an idea throughout its lifetime in the brain. But it is possible to study the process of variation during the replication(transmission) process. It has been suggested by Dennett[7][11][12] that the fidelity of cultural transmission cannot be 100% perfect as there would be no cultural variation. Neither can it be too low as society would easily lose some of the 'Good Tricks'[7][11][12] acquired by individuals. Akaishi et al.[10] attempted to address this problem quantitatively by using multi-agent modeling to study the simple case of foraging.

3.1 Model

In the model[10] described, the actual mechanism for varying ideas was not studied. What was studied instead was the consequences of misinformation.

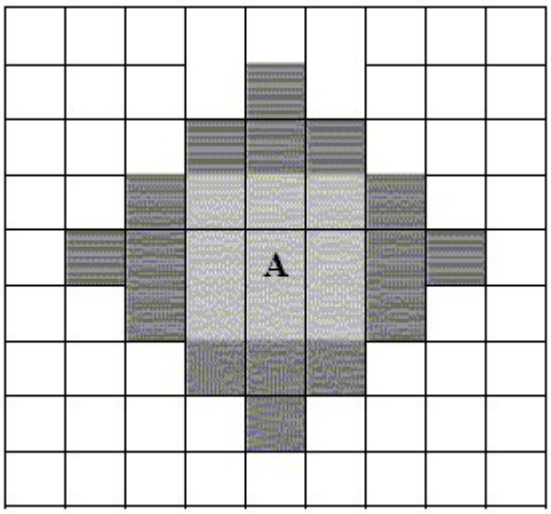

Figure 2: Line of sight is represented by light cells. Dark and light cells represent range of movement. Diagram taken from [10]

We start by defining a 2D grid where initially its resources are uniformly distributed. The grid is also inhabited by agents which are randomly distributed. When an agent occupies a square filled with resource, the resource value of the square goes to zero. When the square is vacated, the amount of resource will increase with each turn until it reaches a maximum value. Each agent has a field of sight, movement range and a resource map describing the location and amount of resources available. The field of sight and range of motion is given by Figure 2. Agents cannot move into a cell occupied by another. Finally, the resource map is obtained through direct sight or via communicating with other neighbouring agents. When an agent receives information that contradicts its existing information, the new information is overwritten over the old.

In summary, the algorithm is as follows:

1. Resources and agents are distributed uniformly over the field.
2. Agents communicate with other agents within their sights.

3. Misperception of information might occur with a given probability.

4. Each agents moves towards the nearest resource based on its own resource map. Agents with no resources in their resource map move in a random direction.

5. Agents get the resources existing in their own cells.

The agents were sent to acquire resources and after a certain number of turns, the total amount of resources acquired was recorded. This amount was used to calculate the fitness level of the society. The more resources the group acquired, the fitter they were deemed to be.

A distinction was made between two kinds of misinterpretation. There was direct misinterpretation which was caused by error in obtaining information from its surrounding environment and indirect misperception which was caused by error in exchanging information between agents.

3.2 Isolated Direct Misperception

The first scenario that was studied was the case of direct misperception with no communication. In this case, there was no communication between the agents and imperfect direct perception of the resources. In order to quantify direct misperception, the researchers used a direct misperception parameter known as the direct misperception rate. The value of this rate relates to the probability of misperceiving the resources directly where 0% means perfect sensing and 100% means that the sensing of the resources will always be wrong.

The result was that a direct misperception of 1% caused a 35% increase in fitness compared to a direct misperception rate of 0%(Figure 3). What was concluded by the researchers was that direct misconception diversified individual behaviour which increased the search area. Next, the growth of fitness by moving average (Figure 5,left)was shown till about 10000 turns. In both cases there was an initial jump for both the 10% rate and the 1% rate. The initial higher rate for the 10% case was because the average search range for each agent for the 10% rate was higher so it could gether resources more quickly. However, it started to reduce after 2000 turns as the negative effects of a higher misperception rate started to dominate.

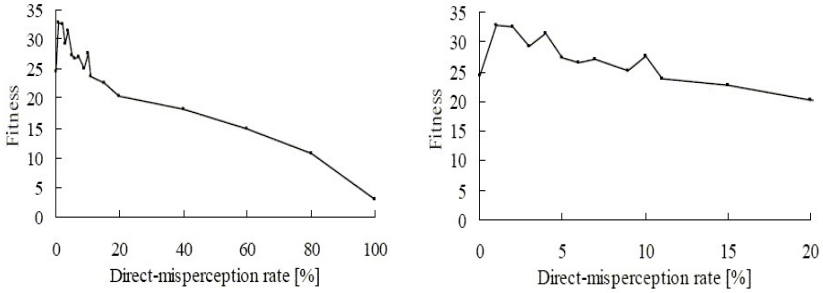

Figure 3: Direct misperception with no communication. The figure on the right shows the fitness in more detail in the 0-20%range.

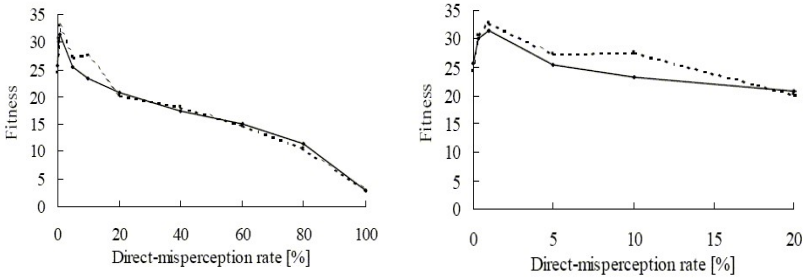

Figure 4: Direct misperception with communication. The figure on the right shows the fitness in more detail in the 0-20%range.

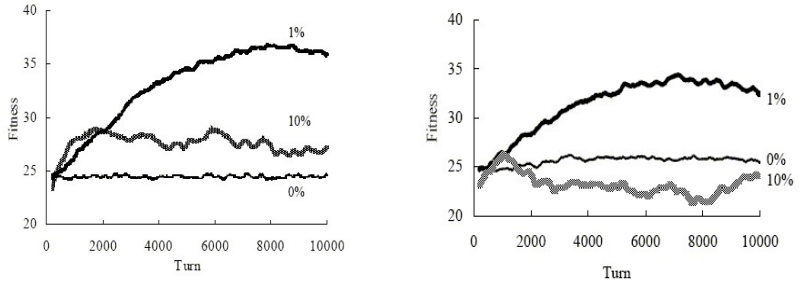

Figure 5: Growth of fitness for the case of no communication on the left and perfect communication on the right. Source of all figures [10]

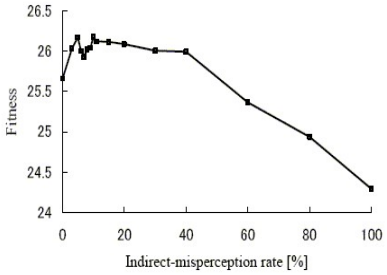

Figure 6: Effects of imperfect communication[10]

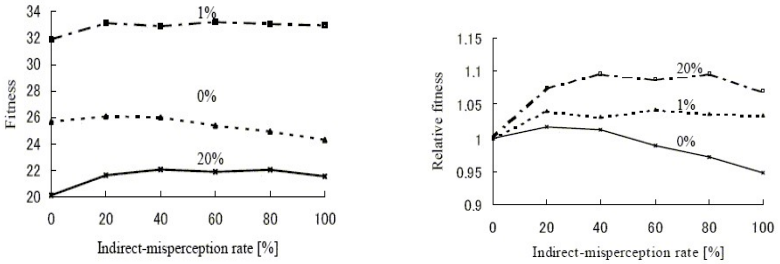

Figure 7: Correlation effects. Relative Fitness plot is on the right.[10]

3.3 Direct Misperception with communication

Next, they attempted to turn on accurate communication between the agents. There was an actual reduction in fitness levels for direct misperception rates of less than 20%(Figure 4). The conclusion given was that direct communication reduced the diversity in behaviour. The fitness growth was next studied(Figure 5,right). There was a sharp drop in fitness for the 10% direct misperception rate as communication amplified the negative effects of direct misperception.

3.4 Indirect misperception

In order to isolate the effects of miscommunication only, the direct misperception rate was set to 0%. The indirect misperception rate was set up to relate to the probability of miscommunication. Therefore, accurate communication corresponded to an indirect misperception rate of 0% and a 100%

rate meant that information shared was always wrong. There was a slight increase of 1.5% (Figure 6) compared to the case of perfect communication when the indirect rate was less than 40%.

3.5 Direct and Indirect Misperception

Both effects were studied together. Using a direct misperception rate of 0%,1% and 20%. The fitness level was plotted for a range of indirect rates. The fitness for the 1% direct misperception rate line increased by 1.5% when the indirect rate was 20%(Figure 7,left). The relative fitness (Figure 7,right)was also plotted where the relative change of fitness with respect to indirect perception was plotted. The conclusion mentioned in the paper was that miscommunication is an adaptive response to direct-misperception as it hinders the spreading of misinformation.

4 Conclusion

Multi agent modeling is a very useful tool in studying memes. The model described in this term paper is important because it aims to contradict one of Dawkins' assertions[13]. He claimed that for a meme to be successful, it has to have fidelity(accuracy of replication), fecundity(ease of replication) and longevity. The paper[10] claims that perfect fidelity is not important for a meme's success. However, the authors made a confusion between the host's fitness and the memes' fitness. While the two are the same in this model, there could be some instances where the fitness of the meme maybe detrimental to the host. This could be analogous to the case of a virus in a cell. There are also other important implications from the model which the paper mentioned. In the future, there could be some task undertaken by a multi-robot system(mining etc). The paper mentions the possibility of increasing efficiency by introducing errors into the system in both direct sensing and communication.

There were however problems with the paper. Firstly, there should be error bars in the graphs. In collecting statistics for the fitness, the fitness of each agent could be recorded first in order to give a fitness average and variance of the population. Another way is to repeat the simulations many times to give the error of the simulations. Without error-bars, we can never really

know whether the increase in fitness is due to actual misperception effects or statistical anomalies. Another possible improvements of the paper is to study the effects of the size of the grid. Maybe simulation studies could be applied to grids of different sizes to see how these would affect the fitness outcomes.

Besides agent modeling, there are also other kinds of mathematical tools that can be used to study memes. Given the biological origin of the subject, the subject tries to borrow mathematics from population studies[6][14]. Lynch[6] tried to model a 2 body(meme) system using a set of differential equations. However, these methods were beyond the scope of this term paper.

The use of the meme analogy is a very interesting way to model information. However, the field of study, though promising, is not very rigourious at the moment. There are problems with defining what memes really are due to the fact that there is no clear consensus on how to properly define it. There are also problems with trying to carry the biological analogy too far. Memes may share common characteristics with biological systems but also important differences like the type of evolution occurring.

Another problem with the subject of memes is the issue of falsifiability. It would be nice to have a theory that can predict some behavioural patterns rather than just describe it. Besides computational experiments,real life experiments could also be performed to test ideas in meme theory. For example, one could start a rumour and see how far it spreads or play a game of 'Chinese Whispers'. Nonetheless, despite its current problems, memes could in the future be used as an important model to describe the spread of ideas and behaviours in a complex system. One shouldn't dismiss the idea yet since the subject and their methods are still in the infancy stage.

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