Memetics: The Evolution of Culture

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Abstract:
Evolution is caused by replicators, which make copies of themselves, with occasional errors. One can model the evolution of culture using the idea of memes. Memes are the basic unit of culture which is copied from one person to another by imitation. By modifying genetic algorithms to take into account the difference between memes and genes one can come up the algorithms to describe the evolution of culture.

I. Introduction

A. Everybody's Doing It

"Kilroy was here" Anyone who lived between World War II and the Korean War will probably recognize this phrase as well as the drawing in figure 1. One could find this graffito scrawled on walls all over Europe and America. Many thousands of people (who were not named Kilroy) took to writing this phrase and image everywhere they went. No one is sure how this originated but there are several theories. One popular theory was that the original Kilroy was James J. Kilroy a shipbuilding inspector. Riveters were paid by the number or rivets they put in and would mark their progress by making chalk marks at the end of their work. Some workers would attempt to gain extra pay by moving the chalk mark back thus taking credit for the previous workers rivets. James Kilroy put a stop to this by writing "Kilroy was here" at the chalk marks. Later when the ships were in use and sealed portions of the ship were opened up for maintenance, soldiers found that someone named Kilroy had gotten into a seemingly impossible place and left this graffiti.[1]

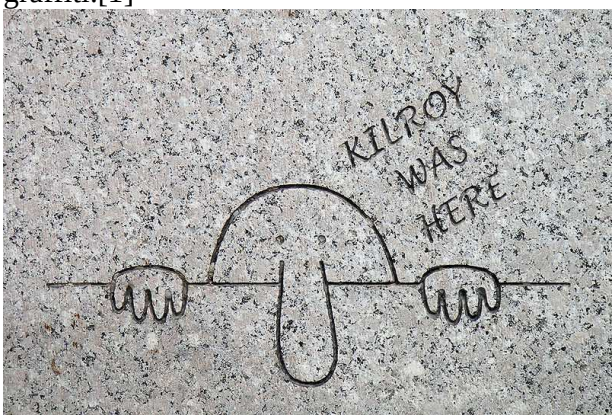


Figure 1: Image of Kilroy engraved in WWII Memorial in D.C. (taken from [1])

In his introduction to Susan Blackmore's *The Meme Machine*, Richard Dawkins recalls a story about how his father taught him to fold an origami Chinese junk out of a square of paper when he was about nine years old. He taught his friends and they in turn taught their friends and eventually the whole school was making these origami boats. His father had learned how to make the them when he was in school. A teacher had taught her class how and they in turn taught the rest of the school, including Dawkins's Father. [2]

One can think of countless other examples of such fads. Younger readers will recognize the phrase "All your base are belong to us." They probably also know quite a

few jokes about Chuck Norris. Anyone who has spent any time on the internet has certainly seen (and quite possibly created) images of cats speaking in broken English. These are all examples of Memes. However memes are much more than silly little fads like these examples. They include any parts of our culture or ideas. This includes language, religion, science, buildings, etc. Any idea or knowledge that can be passed from one person to another.

B. Replicators

To understand the idea of memes, one must first understand the idea of replicators. Richard Dawkins has a good discussion of replicators in his book *The Selfish Gene* [3]. Dawkins posits that at some point in the earth's history a molecule came into being that had the ability to create copies of itself. This molecule, Dawkins refers to as a replicator. Think of the replicator as being made up of long chains of building blocks, which exists in a sea of such building blocks (the primordial soup). If each building block has an affinity for its own kind, then it will attract them out of the soup and create another identical chain of building blocks linked to the first one. If these two chains become separated then you have two replicators which then begin to attract new building blocks to create more replicators. Another possibility is that each building block attracts a specific other building block. This builds the second replicator as essentially a negative of the first, which once separated then builds one identical to the first. DNA, the replicators which govern life on this planet are of the second variety

Sometimes a mistake is made during the copying process. Every descendant of the replicator has the error as well. Mistakes happen in their replications also, so in this way errors become cumulative. Since these mistakes are cumulative, over many generations the replicators can become significantly different from their predecessors. They may also divide into different strains as some will be descendants of replicators with some particular set of mistakes and others from ones without those or with different ones. It is in this way that evolution occurs.

Eventually though the creation of many replicators the building blocks become scarce. This limits the number of replicators and means that the different kinds of replicators must compete for resources. One can define the success of their attemps at competition in the following way: those replicators that become more numerous are successful in competing and those that become less numerous are unsuccessful.

Its easy to think of several factors that govern the success of replicators. The first of these is longevity. Longevity can be defined as how long any individual replicator stays in existence. It should be quite obvious that if all other

factors are equal and one replicator "lives" for a year and another "lives" for a day that the former will far outnumber the latter. This is true not only because there are more older individuals still around of the species with greater longevity, but also because each individual has more time to generate copies of itself. Another property that governs the success of a given species of replicator is the rate of replication. If one species of replicator copies itself every minute and another one copies itself every hour, it is easy to see that the first one will far outnumber the second one even if the second one lives much longer than the first (within some limits). The speed of replication is known as fecundity. A third factor that determines the success of a species of replicator is the copying fidelity. If one makes a mistake often and another makes one very rarely then the latter will outnumber the former. Mistakes in replicator not only lose the individual that has the mistake, but also all of its descendants, as well as any additional descendants that it would have had without the mistake. This seems odd at first that evolution would favor those replicators that are less likely to evolve (since evolution is caused by those very mistakes that are selected against.) It can be understood in the sense that evolution is "bad" for the original species. If species X evolves into species Y, it is by definition no longer species X and so this process is bad for species X.

C. Memes: Replicators in the Human Mind

In the previous section we considered physical replicators in a sea of resources that served as raw materials. These need not be the only replicators. In *The Selfish Gene* [3] Dawkins posits a new kind of replicator, which he calls a meme. It comes from the Greek word mimeme which means imitation. He chose it specifically to be a monosyllable that sounds a bit like gene. He suggests that memes are the basic unit of culture, as genes are the basic unit of genetic information. Rather floating in a sea of building blocks, memes exist in human minds and replicate by transferring to other minds. Memes replicate though imitation. People tell each other their ideas, or they write them down and someone reads it later. Memes must compete as physical replicators do, but instead of competing for raw materials, they must compete for time. People have to spend time communicating them to others. Like physical replicators, memes evolve through mutation. Their evolution is guided by longevity, fecundity and fidelity just as with other replicators.

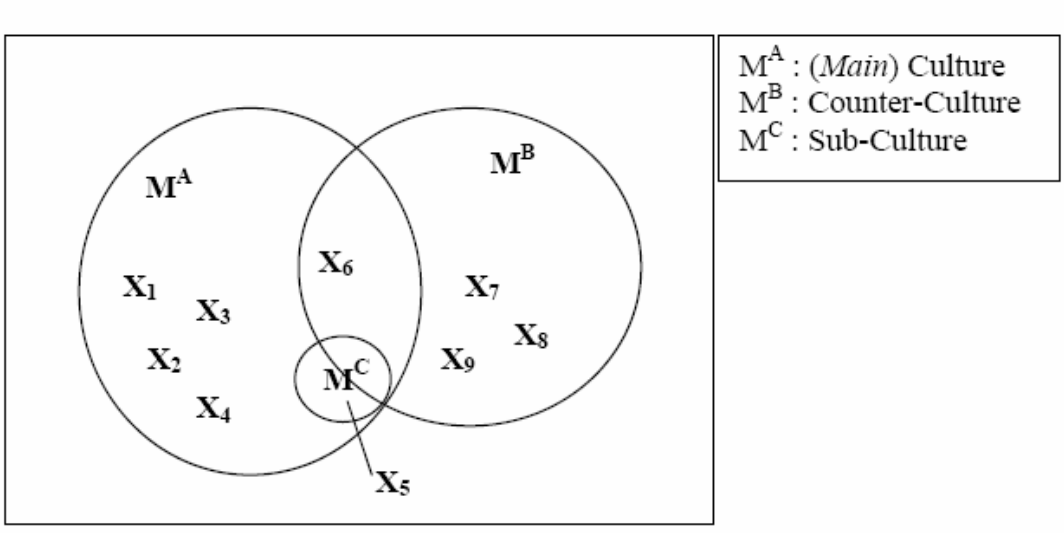
II. Methods

A. A Definition Of Culture

Thus far we have the general idea of memes, but in order for them to be useful as an analytical tool for looking at culture we must be more formal in our discussion of them. The following analysis of culture comes from [4].

One can Define $M=\{X_1, X_2, X_3,\ldots\}$ as a set of cultural institutions in a certain society. The Cultural institutions, X_i can be ways of life, religious beliefs, traditions, music, etc. M is dynamic as the society is constantly changing as people move in and out of an area and as the society evolves. The cultural institutions themselves are made up of cultural objects x^i_j such that $x^i_j \in X_i \in M$. The cultural objects are material objects (buildings, works of art, etc.), distinctive forms of behavior(rituals, prayer, songs, etc), and systems of distinction (classifications, histories, etc.).

On can view a society of being made up of the dominant culture, plus countercultures and subcultures. A counter culture opposes the dominant culture ideologically through political actions, philosophies, etc. A subculture can serve as a critique of the dominant culture, without being explicitly opposed to it and remaining part of it. We can extend our view of a society to include these other cultures such that $S=\{M^A,M^B,M^C\}$. To illustrate this Figure 2 shows a Venn diagram such a community. We can then think of cultural evolution as the changes of the various levels of societal description: cultureal objects ($x_m \leftrightarrow x_n$), cultural institutions ($X_p \leftrightarrow X_q$) and cultures ($M_A \leftrightarrow M_B$)



2: Venn Diagram of Culture in many scopes of description from [4]

B. Memetic Algorithms

Algorithms for modeling the evolution of culture have been developed. They are based on genetic algorithms that have been modified to take into account the differences between genes and memes. Memetic algorithms (MA) can be categorized into 3 different generations:

1st generation: The first generation of MA refers to hybrid algorithms, a marriage between a population-based global search (often in the form of an evolutionary algorithm) coupled with a cultural evolutionary stage. This first generation of MA although encompasses characteristics of cultural evolution (in the form of local refinement) in the search cycle, it may not qualify as a true evolving system according to Universal Darwinism, since all the core principles of inheritance/memetic *transmission*, *variation* and *selection* are missing. This suggests why the term MA stirs up criticisms and controversies among researchers when first introduced in [5].

[2] 2nd generation: Multi-meme [9], Hyper-heuristic [8] and Meta-Lamarckian MA [14] are referred to as second generation MA exhibiting the principles of memetic *transmission* and *selection* in their design. In Multi-meme MA, the memetic material is encoded as part of the genotype. Subsequently, the decoded meme of each respective individual /chromosome is then used to perform a local refinement. The memetic material is then transmitted through a simple inheritance mechanism from parent to offspring(s). On the other hand, in hyper-heuristic and meta-Lamarckian MA, the pool of candidate memes considered will compete, based on their past merits in generating local improvements through a reward mechanism, deciding on which meme to be selected to proceed for future local refinements. Meme having higher rewards will have greater chances of being replicated or copied subsequently. For a review on second generation MA, i.e.,MA considering multiple individual learning methods within an evolutionary system, the reader is referred to [15].

[2] 3rd generation: Co-evolution and self-generation MAs introduced in [17], [9] and [10] may be regarded as 3rd generation MA where all three principles satisfying the definitions of a basic evolving system has been considered. In contrast to 2nd generation MA which assumes the pool of memes to be used being known *a priori*, a rule-based representation of local search is co-adapted alongside candidate solutions within the evolutionary system, thus capturing regular repeated features or patterns in the problem space

(This is quoted from [5], references are as referred to in [5] see there for papers referenced)

The main difference between a first and second generation algorithm is that a second generation algorithm uses both genetic and non-genetic transference of memes. This is because although memes can transfer from parent to child in the usual genetic manner (vertically), they can also transfer from peer to peer (horizontally). This horizontal transmission causes a refinement in the memes before they are passed on to children. Figure 3 shows an example of a second generation Memetic algorithm.

Algorithm 1 Memetic Algorithm (2^{nd} generation)

1: Generate an initial population
2: Initialize the meme pool
3: **while** Stopping conditions are not satisfied **do**
4: *Evaluate* all individuals in the population
5: *Evolve* a new population using stochastic search operators
6: *Select* the subset of individuals, Ω_{il}, that should undergo the individual improvement procedure
7: **for** each individual in Ω_{il} **do**
8: *Select* a meme from meme pool
9: *Perform* individual learning using the selected meme
10: *Proceed* with Lamarckian or Baldwinian learning
11: **end for**
12: **end while**

3: Example of a 2nd Generation Memetic Algorithm from [5]

C. Diffusion of Memes

Cellular genetic algorithms (CGA) use a decentralized structure where each chromosome can only mate with other chromosomes within a certain neighborhood. This mimics the fact that individuals can only mate with others that are physically near to each other. This is accomplished where each individual has a pool of mates that consist of its neighbors, which in turn have their own overlapping pool of mates consisting of their own neighbors.

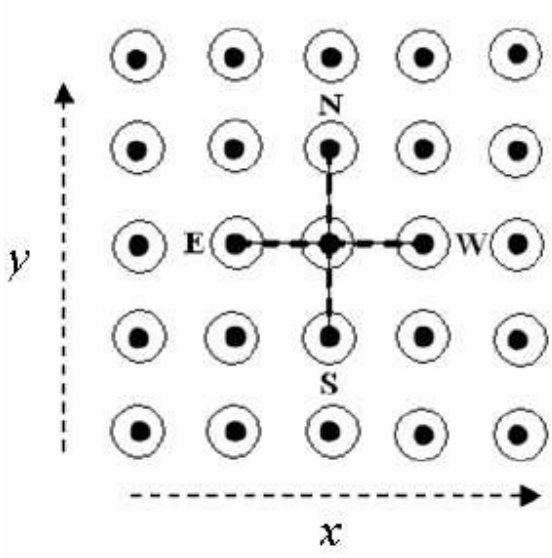


Figure 4: Neighborhood structure in Cellular Genetic Algorithm from [5]

This provides diffusion across a grid. Figure 4 helps illustrate this.

Algorithm 2 Diffusion Memetic Algorithm

```
1:  procedure DIFFUSIONMA
2:      Initialize-Meme-Pool;
3:      pop = Create-Grid (WIDTH * HEIGHT)
4:      for x = 1 to WIDTH do
5:          for y = 1 to HEIGHT do
6:              initialize pop(x, y)
7:              pop(x, y).fitness = Evaluate(pop(x, y))
8:              pop(x, y).meme = Random-Meme;
9:          end for
10:     end for
11:     while termination condition is not satisfied do
12:         for x = 1 to WIDTH do
13:             for y = 1 to HEIGHT do
14:                 /*Gene transmission*/
15:                 parent1 = pop(x, y)
16:                 parent2 = Select(Neighbors(x, y));
17:                 child = Crossover(parent1, parent2)
18:                 child = Mutate(child)
19:                 child.fitness = Evaluate(child)
20:                 /*Meme transmission*/
21:                 child.meme = Meme-Selection()
22:                 if (generation mod α = 1) then
23:                     /*Individual learning*/
24:                     child = Local-Improvement(child)
25:                     if childls.fitness > child.fitness then
26:                         replace pop(x, y) with childls
27:                     else
28:                         replace pop(x, y) with child
29:                     end if
30:                 else
31:                     replace pop(x, y) with child
32:                 end if
33:             end for
34:         end for
35:     end while
36: end procedure
```

Figure 5: Diffusion Memetic Algorithm (DMA) from [5]

Nguyen et al. [5] developed a diffusion memetic algorithm (DMA) based on CGA, using a second generation MA. Their DMA is shown in figure 5. In their algorithm the population is arranged in grid and given initial memes. Each cell mates with one of its neighbors to produce an offspring which replaces the

parent. A learning phase occurs when an individual can adopt a meme from one of its neighbors.

III. Results

Nguyen et al. [5] ran a numerical simulation using the DMA discussed in the previous section. They initialized a 10 by 10 grid placing memes at 4 locations. The memes are deemed to have better solution qualities based on some reward metric for a natural selection process. Figure 6 shows the results. One can see that the memes diffuse to neighboring cells with each generation until the fill nearly the whole grid.

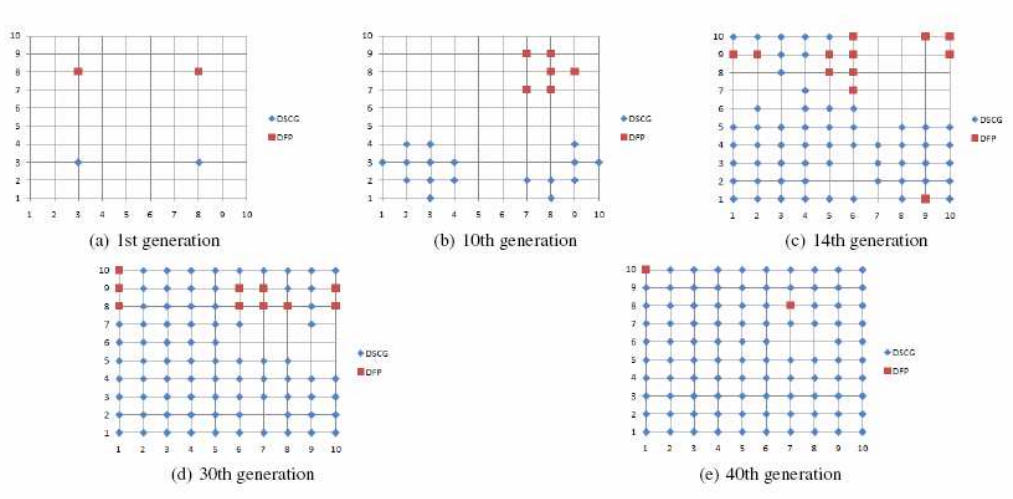


Figure 6: Memetic Map across generations of DMA from [5]

IV. Conclusions

We have seen that one can use the idea of replicators, which are usually used in genetics to apply to the evolution of culture by way of memes. Using the idea of memes we can model the evolution of culture using modified genetic algorithms, to take into account the fact that memes can travel horizontally (peer to peer)as well as vertically (parent to child) whereas genes can only travel vertically

References:

1. http://en.wikipedia.org/wiki/Kilroy_was_here
2. Blackmore, S. (1999). The Meme Machine. Oxford: Oxford University Press
3. Dawkins, Richard (1976) The Selfish Gene, Oxford University Press
4. Situngkir, Hokky (2004) On Selfish Memes. arXiv:nlin/0404035v1 [nlin.AO]
5. Nguyen Q-H, Ong Y-S, Lim M-H (2008) Non-genetic transmission of memes by diffusion. In: 10th Annual conference on genetic and evolutionary computation (GECCO'08), Atlanta, GA