

A description of a complex system

Many times, we use the term *complex system* and refer to *complexity science* or *complexity theory* in a context where our readers might not be well read on the subject.

Contemplating this, it struck my mind that a football¹ match is a good example of a complex system.



Figure 1. Players act in every time step based on their impression of circumstances in the preceding time step.

Let's make the mind experiment that we have videotaped an actual game, where a goal is scored. Now we show this video to someone who does not know of the game and its result.

One minute before a goal is scored; we stop the film and ask the person for a description of what will happen in the following minute. Of course, the test person cannot give such a description because there are too many factors that are unknown to him. He can guess at the first few seconds, but beyond that the probability is low of guessing right, because he does not know what the players think, etc. Thereafter we continue to look at the video of the following minute until the goal is scored. Then we ask the test person to describe to us how that goal came to be. Now it is easy for him to describe patterns in the preceding minute and perhaps even the preceding several minutes that led to the goal.

This is typical of a complex system: we cannot predict what will happen, but when it's happened it is easy to spot patterns that lead to it.

If we in some way could have each player governed by some sort of random generator then they would run around changing direction and speed erratically, without any discernable patterns. That would be a chaotic system. It is hard to see how anything meaningful or interesting would come out of that.

There is more to this example that is typical of a complex system:

¹ Association football, NOT American football!

1. It is an open system, since the players of the two teams on the field are affected by weather, the audience, the coaches, their spouses and sponsors, the janitors of the arena, etc.
2. The players act in every time step based on the impressions they have (including forethought) of circumstances and of their immediate environment in the preceding time step. In a way, this resembles the workings of cellular automata or the action of Army ants.
3. The interaction between the players are more important than who the players are. In fact, the interaction is the whole thing.

Chaos theory is a subpart of complexity theory. What this means is simply that a complex system may contain areas of chaos. This could perhaps be action of the players during warm-up before the game. A complex system may also contain areas of apparent order. This could be the line-up of the teams after the game is finished. There are also several entrained action patterns used in specific situations, such as penalty kicks, that can be said to be ordered.

However, largely, the beauty of a game of football lies in the emerging patterns created by actions taken by individual players based on their understanding of the situation at hand in the very moment they act.

If it's the complexity and emerging patterns of a game of football that makes the game interesting, it is perhaps in the same way, the known action of a military tattoo that makes such events so dull to watch.

Returning to the game of football, what is it that governs the players, where do all the elegant patterns come from? Well, it's not from a team leader or upper management, that's for sure. Further, it does absolutely not come from following a plan, for what plan would hold more than a few seconds after playoff?

No, the patterns emerge from the cooperation between players (agents) in their quest for scoring goals, and from keeping the other team from scoring. We see that beside the rules of the game, there are other ordering factors. It is possible to see that the players:

- Are a *real team*
- Have a common *vision* (to score)
- Rely on *self-organization* (except at a few specific occurrences, such as penalty kicks)
- *Tempo* is important for winning a game.

Strangely, we find that the keywords for Dynamic Product Development (DPD): vision, self-organization, and tempo, are important also for the complex action of a football team.