MOVIES AS A TOOL FOR IMPROVING OUR CLASSES

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Cinema and TV series can be a helpful tool to improve some of the aspects in Statistics classes. Motivation is an obvious point to reinforce by using movies scenes, especially those in which we can find applications of the topics to be taught in class. Also we can use specific scenes to make clearer some notions or ideas in the class. Thinking in a University level, we can find some of the fore mentioned scenes in a small number of films and a few TV series. In this communication we state our ideas about how to use movies to improve our classes and we illustrate them with some concrete examples of scenes which can be used in a University-level class.

INTRODUCTION

Movies (TV or cinema) are becoming a useful tool in teaching practice. Some disciplines have got even a cinema genre or sub-genre, like Law, Medicine or Economics. There is not such a variety of movies in Mathematics, and especially in Statistics and Probability. But we present some examples that can be used to improve our classes.

There are some web resources oriented to explore the links between cinema/television and Mathematics. Some of them, like Martín and Martín, 2007, and Allen, 2004, compile an exhaustive catalogue of references in cinema and television regarding Mathematics and mathematicians. Other authors perform critical analyses about recent movies or TV series (Real Sociedad Matemática Española, 1999). We also can find one book, in Spanish, specifically devoted to this topic (Población, 2006). Within a statistical context there are few resources, but, properly used they can provide good results to improve our classes.

In this paper we describe some of these movies and TV series and we analyze how they can be used to improve the professional practice of the teacher.

NOTORIOUSLY USEFUL REFERENCES

Monty Hall paradox

There are notorious references to Probability Theory in some movies. The most well-known is the Monty Hall paradox. This has been deeply analyzed in many papers (for instance, Selvin, 1975, Gillman, 1992 or Barbeau, 1993, and a recent study by Contreras et al., 2009). We suggest that also fictional live-animation resources should be analyzed from this point of view.

We can find the Monty Hall paradox in two recent references. The first one is the TV series "Numb3rs" (created by Nicolas Falacci & Cheryl Heuton, first Season released in 2005) and the second one is the film "21" (directed by Robert Luketic, 2008). Even though the conditional probability is a topic that is usually introduced in Secondary education, basic probability courses at the University-level start again describing conditional probability and its implications. The Monty Hall paradox has been described as a best starting point. This paradox is very well-known by the scientific community and in the United States popular culture, but it is rarely known in other cultural contexts like, for instance, Spain, as far as we have checked in experiences not only with our students but also in Conferences with other Spanish teachers and professors.

In Episode 13 of Season 1 of "Numb3rs" ("Man Hunt") mathematician Charlie Epps and also in a sequence of "21" professor Micky Rosa provide a brief simple explanation of Monty Hall paradox that can be used as an introduction and/or motivation to deeply study the concept of conditional probability and the way we understand the real meaning of the concept. We can suggest to the students variations on the original Monty Hall problem (for instance, what happens if the host does not know where is the car?) and then compare the students' prior opinion with the result obtained by calculating the probability.

Game Theory

An easy reference to Game Theory can be found in two movies: "WarGames" (directed by John Badham, 1983) and "A Beautiful Mind" (directed by Ron Howard, 2002). The former was a

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youth-oriented movie which can be hardly watched by today's teenagers without blushing, due to all the machinery regarding computers. But when the young hacker Lightman makes the computer WOPR learn that the Tic-Tac-Toe is not a just game is still valid to discuss with our students the concept of strategy in Game Theory and to show how the hypotheses for a perfect game are not always easy to be fulfilled. We can practice with other games as Brussels Sprouts (in which the winner depends on the number of initial spots and the player who starts the game) so that our students can test their assumptions about the influence of initial conditions on the result of the game.

On the other hand, "A Beautiful Mind" gives us the chance to talk about Nash equilibrium and cooperative games. One of the most mathematical sequences in the film shows Nash explaining to his colleagues the right strategy for all to have success with a group of girls in a pub. In our opinion this could be a very good starting point to discuss with our students the essence of Game Theory, and which are the main components of this type of studies.

Randomness

Of course, other episodes in "Numb3rs" provide direct references to probability, but let us just remark Episode 5 in Season 3 ("Traffic"). This episode shows an interesting sequence that can motivate our students to ask themselves about the concept of randomness that they have acquired. Misconceptions about equiprobability usually lead students (see, for instance, Batanero et al., 1996) into serious difficulties to understand the concept of radomness.

The fore mentioned sequence in "Traffic" shows Charlie Epps making the students choose between two possible distributions of rain drops on a surface in order to determine in which there is randomness and in which not. One of the surface images shows the drops almost uniformly spread all over the surface, with similar separations among the drops. The second one shows an unclear pattern over the surface of the drops. We can use this sequence as a starting point to develop activities involving concepts as random sample, rare events, uniform probability distribution, etc.

Animation Series

Many more references, but some of them very simple, can be found in episodes of "The Simpsons". This animation series has many mathematicians in the team of writers and it has a lot of references, quotes and shortcuts related to Probability and Statistics. Maybe more of them are appropriate to be used in Secondary-level class rather than in University. A similar case occurs with "Futurama", also created by Matt Groening. This animation series has more complex mathematical references than those in "The Simpsons". But from the statistical point of view, we do not observe, in general, a higher degree of difficulty.

Other brief references

Many other brief notorious references related to probability can be found in additional movies. In particular, there are many references related to gambling: roulette, cards, dice, lotteries, etc. For instance, in "Casino" (Martin Scorsese, 1995) we can see how Nicky Santoro asks Rothstein, the expert handicapper, about the probabilities of winning in various games in the casino. In general, these types of references are easy to understand; nevertheless they can lead us to suggest our students to try more complex probability calculations based on the problems stated in the movie.

INDIRECT REFERENCES

In this section we analyze other references that can be found in the movies that are indirect rather than evident in the way they present Statistic/Probability concepts. To identify and to understand those references is a good task for students at the University level.

We can start with a version of the prisoner's dilemma that can be found in "In the name of the father" (directed by Jim Sheridan, 1993). When Gerry Conlon and Paul Hill are arrested, the police, after lots of illegal procedures, force both of them to confess. Obviously, in the case of this movie the hypotheses of prisoner's dilemma are not totally fulfilled but we can show our students the strategies of the "players". Both Gerry and Paul initially try to deny all the charges, but when the policemen deceive them into thinking that the other one had already confessed, both acknowledge that they are guilty. Apart from the brutality of the police in the film, we can use this

argument to show the optimal strategies in the prisoner's dilemma much clearer than, in my opinion, in any other example.

There is also another good sequence related to Game Theory in "The good, the bad and the ugly" (directed by Sergio Leone, 1966). This one has been recently pointed out by Población (Real Sociedad Matemática Española, n.d.). The final sequence starts with a famous five-minute Mexican standoff while the three bandits calculate alliances and strategies to know who to kill. Each have (or are supposed to have, we do not reveal the plot) only one bullet in his gun and the name of the grave containing the treasure is written in a stone in the center of the triangle they form. Again, we can discuss about hypotheses of perfect games, differences in the information of the players, different probabilities in the lotteries of the game, the concept of utility, and many other aspects in Game Theory. And, of course, we will enjoy this ten-minute famous sequence.

"Pi" (directed by Darren Aronofsky, 1998) is an independent movie with a lot of mathematical content. From the statistical point of view it is not so fruitful. Nevertheless, there is a strong connection with the basis of uncertainty and imprecise reasoning. For many centuries, Mathematics was conceived as an "exact" science. In the film "Pi" we can see how mathematicians try to deal with imprecision and inaccuracy. Fortunately, today's scientists in general and mathematicians in particular assume Statistics, Probability or Chaos Theory (also present in "Pi") as another natural part of Mathematics, focused on dealing with uncertainty and/or impossibility of exact prediction.

The answer given in "Pi" to Max Cohen's interests on discovering the underlying rules that govern the world is an optimist one, in the sense that, finally, the tortured mathematician is able to accept that not everything has to be predictable and humans have to adapt themselves to live with uncertainty.

This could be much more a philosophical rather than a statistical question for our students. Our experience when using this film with the students is very fruitful in the sense it helps them to think about how Mathematics can be also used to model unpredictable phenomena.

Also "Gattaca" (directed by Andrew Niccol, 1997) discusses determinism. In this case, the biological determinism in a future world in which newborn children are classified based on their genetic map. The film is very helpful for us to encourage our students to think about differences between causality and probability. Moreover, if we have a group of students with wider interests we can also discuss with them about the importance of binomial biological-social context (there are lots of statistical analyses about the impact of social differences on studies, jobs, way of life, etc.) in developing someone's personality, and why not, the impact of chance.

Another quite recent film using Mathematics, especially Mathematical Logic, in the plot is "Fermat's Room" (directed by Luis Piedrahita & Rodrigo Sopeña, 2007). Main characters are closed within a squared room whose walls approach as they spend time solving several puzzles which are posed by an unknown guest. The first enigma is a classical logical puzzle about three opaque boxes one containing mint candies, another anise candies and the third a mixture of both mint and anise. But the boxes are all mislabeled. The question is how many candies are needed to be extracted to determine the correct position of the labels.

It is interesting, if our students have not seen the movie before, to stop the sequence at this point and ask for their opinions. Many of them, as one of the characters in the movie (the so-called "Galois"), are convinced that this is a problem on probabilities. Obviously, it is not. But we can pose new problems by making variations on this one which can be solved by using probabilities. For instance, if we are told that "some" (and not "all") of the boxes are mislabeled, what is the probability that we have to extract half of the candies from one box to determine correct labeling? This is an interesting activity, not only to pose problems but to let the students pose and try to solve new problems from this one.

"The Oxford Murders" (directed by Álex de la Iglesia, 2008), a movie based on the homonymous novel by Guillermo Martínez, is another interesting film to think about uncertainty, much more from the philosophical point of view. But the main topic in the film is the search of truth, and the possibility of finding it. Statistically, there is not so much. But we have worked with our students on probably the most exciting sequence in the film. Starting from a concert hall, the camera follows, one by one, all the main characters in the film, in a continuous sequence, by jumping from one character to another in just a few squared meters in the center of Oxford (concert

hall, street, bookstore, street, and guests' house). What is the probability of such people to meet right there at same time in a city like Oxford? Funny questions like this one can lead us to go deeper with our students in the analysis of coincidences.

"Sliding doors" (directed by Peter Howitt, 1998) focuses on this topic of the consequences of a "rare event". This movie is based on a relatively unknown Spanish film from the 1940's never released abroad, "La vida en un hilo" (directed by Edgar Neville, 1945). The plot is based on comparing two different lives of a woman, depending on the decision she makes about an apparently unimportant moment in her life. Then, the question is: have you ever thought about how your life is dependent on very improbable facts?

This is a topic also related to determinism, as in "Gattaca", because the movie shows how probability plays a crucial role in day-by-day actions that are not apparently significant, but the addition of all these actions can produce totally different results depending on the conditional probabilities that affect them.

CONCLUSIONS

This paper does not pretend to be an exhaustive catalog of movies or TV series with statistical references. Our initial goal was different for two reasons. On one hand, to underline several aspects of some movies and TV series related to Statistics and Probability. Part of them are obvious, but nevertheless should be mentioned and briefly analyzed. The rest of the references are not obvious but indirect. They are what we considered to be more interesting when teaching at University Levels, because in those cases what the student has to do is more than only to watch the film. The student has to discover the relationship between the statistical concepts and the cinema language: how they are used, how the screen writer uses Statistics and Probability in constructing the play, etc.

Our second goal was to express, based on our experience, the conviction that cinema can be used to improve the motivation and knowledge of our students. Most of Statistics classes at University are not taught within mathematical studies (Engineering, Experimental Sciences, Biomedical Sciences, etc.), whose students are poorly motivated. Therefore, using brief sequences of movies to introduce our concepts is a very good tool for gaining motivation, because it helps the students to see that Statistics is not simply a branch of Mathematics but a very real-life-applied science.

Moreover, difficult concepts as conditional probability, game equilibrium, and randomness vs. causality can be easier to understand if we use movies sequences to illustrate our explanations. These sequences can be used in different type of classes: expositive classes as well as inductive classes, for instance, Problem-Based-Learning classes. We have shown two possibilities: using the movie only for exposing the initial problem (e.g., candy box problem in "Fermat's Room") or using the movie both for the initial exposition and for the resolution (e.g., randomness in "Numb3rs"). We plan to give a more detailed compilation of activities related to each of the movies we have analyzed here in a forthcoming work.

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