Project Report

On

MATHEMATICAL MODELLING OF FOOTBALL

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

MATHEMATICS

by

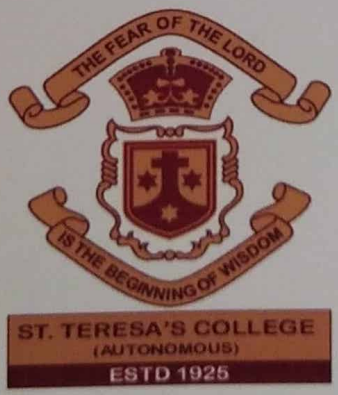
SREELAKSHMI U.S

(Register No. SM20MAT015)

(2021-2022)

Under the Supervision of

VEENA V.S



DEPARTMENT OF MATHEMATICS

ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM, KOCHI - 682011

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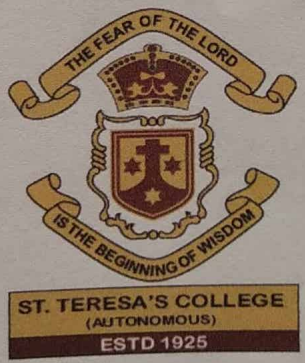

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CERTIFICATE

This is to certify that the dissertation entitled, **MATHEMATICAL MODELLING OF FOOTBALL** is a bonafide record of the work done by Ms. **SREELAKSHMI U.S** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Mathematics** at St. Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University, Kottayam. No part of this work has been submitted for any other degree elsewhere.

Date: 27-05-2022
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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of **SMT.VEENA V.S**, Assistant Professor, Department of Mathematics, St. Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

Place : Ernakulam **SREELAKSHMI U.S**

Date: **SM20MAT015**

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First and foremost,I would like to thank God almighty, for the successful completion of my project.

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Place : Ernakulam. SREELAKSHMI U.S

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Contents

Chapter 1

Introduction

A mathematical model describes a system using mathematical concepts and language. In modelling our world, we are often interested in predicting the value of variable at some time in future. Such a mathematical model idealizies the real world phenomenon and is never a completely accurate representation. Although any model has its limitations, a good one can provide valuable results and conclusions.

It is the theory and practice that makes football the sports we love. Numbers play an increasingly important role in football. Player and team rankings, assists and goals, possession and passing rate, tackle and intersection frequency are just a few of the stats that feature in match reports. But these numbers are just a starting point. Mathematics is about putting statistics together to allow us to see what is going on. Once we have numbers, mathematics gives us understanding.

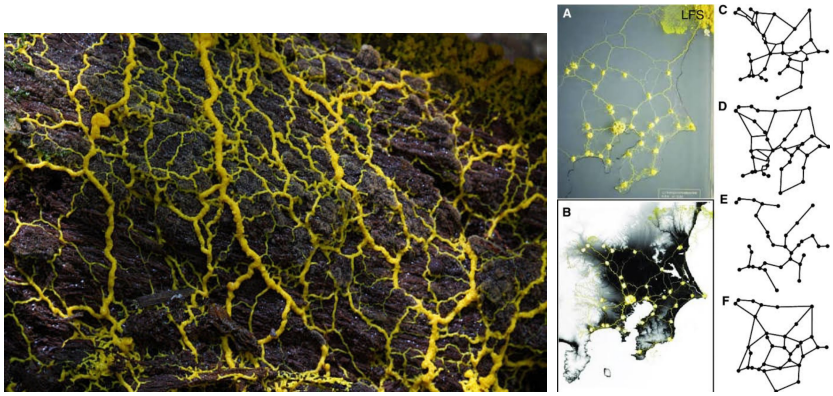
Modelling is a process that uses math to represent, analyse, make predictions or otherwise provide insight into the real world phenomena. Football is the most popular sports. Predicting the results of football matches is interesting to many. It is also interesting as a research problem in part due difficulty, because the result of a football match depends upon many factors such as skills, current score etc. So even for football experts it is very hard to predict the exact result of football matches. In this project we are discussing about the visualization and football Prediction Model using Simple Poisson Distribution.

Chapter 2

How Slime mould build Barcelona (Football Formation)

Slime moulds are single celled eukaryotic organisms. But they can aggregate together to form multi-cellular reproductive structures. Their body is a network of interconnected tubes which is found on the forest floors and trees they can spread over quickly in search of foods and shrink when conditions are bad.

The experiments worked prefectly on slime moulds on building the network of triangles which inspired football formation.



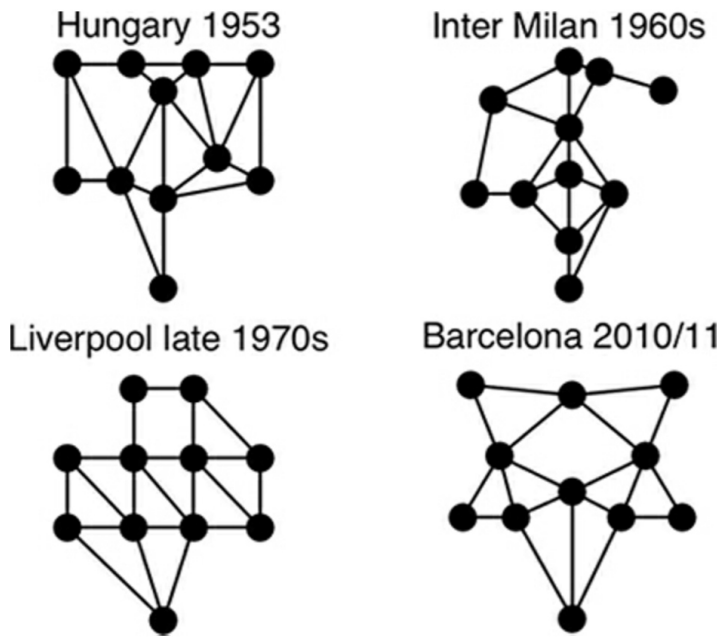


Figure: Four formation networks from football history.

In the Hungary 1953 formation, Hidegkuti is the central player directly behind the front four. For Barcelona 2010/11 Lionel Messi played as the center most of the three forwards, Iniesta and Xavi were the left and right of midfield respectively, and Busquets played in the center just in front of the back four.

Chapter 3

Tiki-Taka Formation

There is a mathematical connection between wide-triangle networks and efficient use of space. The triangulation networks can be used to see how the team breaks the pitch down into zones, the sets of points that are closest to each player. So all the points in a player's zones are those that are closer to that player and no other. This partitioning is known as Voronoi diagram.

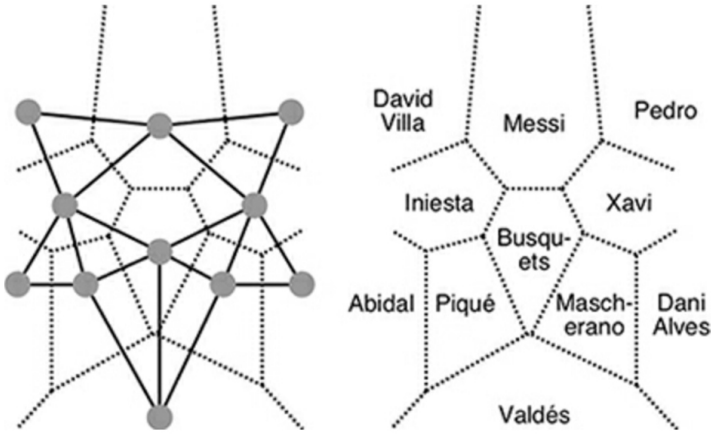


Figure: For Barcelona, the resulting zones are as shown in figure. On the left is the player network, together with the zones it creates (dotted lines). On the right the network is removed, leaving just the zones, and which player played in which zone in 2010/11.

To calculate triangulation, we first use the voronoi diagram to calculate zones. We then take the center points of all the zones in the voronoi diagram (i.e.The players)and draw links between them if they have neighbouring zones,to create a Delaunay triangulation, For Barcelona network, the first and second second minimum spanning tree between them contain most of the edges of the Delaunay triangulation. The Delaunay triangulations tends to maximize the angles in connecting networks, while the voronoi diagram maximises zone sizes. We can switch interchangeably between the two: every voronoi diagram has an equivalent Delaunay triangulation, and vice versa. So when we maximise angles, we maximize zones and vice versa.

Chapter 4

Football prediction model using simple Poisson distribution

4.1 Objectives

How to calculate the probability of any scoreline between teams in a football match and discover how to use it to calculate match odds (Home /Draw /Away). This will help you make more well-informed football predictions and help you find value in various betting markets.

4.2 What is Poisson Distribution?

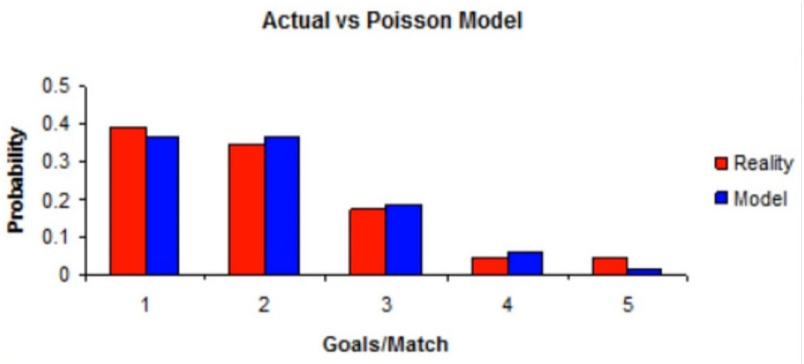
Poisson Distribution is developed in 19th century by French mathematician Simean Denis Poisson. It is a probability theory that uses historical sports data to predict the outcome of a sports event. It measures the likelihood of how many times an event occur during a specific period. Poisson Distribution can help to predict how likely each number of goals scored is.

4.3 Why we use Poisson Distribution?

When bookies set their odds, it is important to know how likely any event is based on past performance. Bookies use mathematical models for this.If you want to take scientific, mathematical approach to betting you should calculate how likely you think a specific game event or all set of events will be. That is the first step for finding value. If you have found something that is more likely to happen than what the bookies predict, that is what value is. Poisson Distribution is the betting which is particularly relevant for games like football, where scoring happens on an incremental scale. It helps you determine the likelihood of each possible score.

4.4 One of the most common uses of Poisson distribution: Calculating football result

To calculate the specific score in football, as well as a win, lose or draw. First we calculate league's average goal expectancy, as well as the attack strength and defence strength for both sides.



4.5 How to calculate goal expectancy

Team's goal expectancy depends on team's attack strength and defence strength, and as well as the opposite team's attack strength and defence strength.

Example: English Premier league. Liverpool(Home) vs Chelsea(Away)

	Goals scored at home by all premiere league teams	Away goals scored by all premiere league teams	Home goals scored by Liverpool	Home goals conceded by Liverpool	Away goals scored by Chelsea	Away goals conceded by Chelsea
Goals	582	436	57	12	34	12
Matches	380	380	19	19	19	19
Goals/Matches	1.532	1.147	3	0.63	1.78	0.63

4.5.1 Calculating attack strength

With these results, we can calculate attack strength for the home and away team.

Attack strength=Team's average number of goals/League's average number of goals.

Home team:

Liverpool's attack strength:3.00 divided by 1.53=1.96

Away team:

Chelsea's attack strength:1.78 divided by 1.147=1.55

4.5.2 Calculating defence strength

To calculate defence strength for home and away team.

Defence Strength=Team's average number of goals conceded/ League's average number of goals conceded.

Home team:

Liverpool's defence strength:0.63 divided by 1.532=0.41

Away team:

Chelsea's defence strength:0.63 divided by 1.147=0.55

4.5.3 Goal expectancy

To calculate the no. of goals the home team scored,

Liverpool's Attack strength * Chelsea's defence strength* league's average number of home goals.

i.e; 1.96×0.41×1.532=1.23

To calculate the no. of goals away team scored,

Chelsea's Attack strength * Liverpool's defence strength* league's average number of away goals.

i.e.; 1.55×0.55×1.147=0.997

4.6 The Poisson formula

The Poisson formula is:

P**(k events in interval)=** $\lambda^k e^- \lambda / k!$

In this formula:

P **is the probability**

k **is the no.of occurrences in the interval (no.of goals)**

λ **is the expected number of goals**

e **is the Euler's number (**e**=2.71828...)**

$k!$ **is the factorial of k**

No game ends 1.23 vs 0.997,this is the average. Poisson Distribution allows to use these figures to distribute 100% of probability across a range of goal outcomes for each side.

4.7 Probabilities

Liverpool Goals	Probability	Chelsea Goals	Probability
0	0.29229258	0	0.36898474
1	0.35951987	1	0.36787778
2	0.22110472	2	0.18338707
3	0.09065294	3	0.06094564
4	0.02787578	4	0.0151907
5	0.00685744	5	0.00302903

4.8 Predicting the match outcomes based on these probabilities

To get each possible score, simply multiply the probability of each possible score by each team by the probability of each possible score by the other team. That gives you the following distribution:

Number of goals	Chelsea goals	0	1	2	3	4	5
Liverpool goals	Probability	0.37	0.37	0.18	0.06	0.02	0.003
0	0.29	0.1073	0.1073	0.0522	0.0174	0.0058	0.00087
1	0.36	0.1332	0.1332	0.0648	0.0216	0.0072	0.00108
2	0.22	0.0814	0.0814	0.0396	0.0132	0.0044	0.00066
3	0.09	0.0333	0.0333	0.0162	0.0054	0.028	0.00027
4	0.03	0.0111	0.0111	0.0054	0.0018	0.0006	0.00009
5	0.006	0.0222	0.0222	0.00108	0.00036	0.00012	0.000018

4.9 Convert estimated chance into betting Odds

To calculate the chance of a Liverpool win, we add all the red squares from the table above : that gives us an estimated chance of 0.4142 or 41.42%

To calculate the chance of a Chelsea win, we add all the green squares from the table above : that gives us an estimated chance of 0.29867 or 29.87%

To calculate the chance of a draw, we add all the yellow squares from the table above : that gives us an estimated chance of 0.286118 or 28.61%

To convert each of these into odds,we use the following formula.

Odds=1/(probability)

Liverpool win:1/(0.4142)=2.4390

Chelsea win:1/(0.29867)=3.3333

Draw:1/(0.286118)=3.4483

Chapter 5

Conclusion

The prediction in football has been an interesting problem and tried to find a solution for it. Our aim has been to derive a method for estimating the probabilities of football results with the potential to achieve the positive expected return when used as the basis of a betting strategy against bookmakers' odds. Our basic model is a simple bivariate Poisson Distribution for the number of goals scored by each team, with parameters related to past performance.

The purpose of the work described here for predicting the results of football matches with view to betting in the primary market on win, draw or lose outcomes. There are all ways of looking at football, and they are all part of maths. It is when we put them together that we truly understand the beautiful game.

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