

Learning and Analytics in Intelligent Systems 13



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Machine Learning with Health Care Perspective

Machine Learning and Healthcare

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will give a glimpse of how the CDSS developed through the years. (2) Emerging trends in CDSS: here the recent evolution of CDSS is discussed. (3) Problems in the implementation of CDSS: will be a summary of key disruptions, barriers, accelerators in the CDSS development. (4) Types of CDSS: will speak of different categories of CDSS that have evolved. (5) Artificial Intelligence (AI) and CDSS: is about the recent developments in CDSS with AI algorithms. (6) Predictive analytics in CDSS: this again is about the more recent developments that makes CDSS indispensable in healthcare.

2 History and Development of CDSS

Decision making has always been an important task in any process but in the case of any clinical process it is not only important but could be crucial as well. That is why there has been so much of interest in creating a system of decision support for clinicians. The research literature on CDSS has been steadily on the rise [1, 2]. There also has been studies on the origin and evolution of CDSS to understand the background of the development and to find the future possibilities [3–6]. To trace the origins of CDSS will also involve the tracing of the origins of a decision making system since the formalisation of decision making is the origin of a decision making system [7].

2.1 History of Decision Making

The origins of CDSS should be traced back to the origins of decision making. In ancient times, people depended on oracles and fortune tellers to find the outcome of their choices. The first use of permutations and combinations actually traces back to the study of cryptology by the Arabs between the 8th and 13th centuries [8]. The mathematics of decision making appeared first with the problem of points (also called the problem of division of the stakes) in the book ‘Summa de arithmetica, geometrica, proportioni et proportionalità’ written by Luca Pacioli in 1494 [9]. The problem of points is a classical probability theory problem that describes the expected value. The second published attempt to the problem of points is the ‘La Prima parte del General Trattato di numeri et misure’ by Niccolo Tartaglia in 1556. The next major contribution is that of Hieronymus Cardanus (Girolamo Cardano) in his book ‘Practica arithmetice et mensurandi singularis’ which was probably composed in 1539 but was published in 1663. A finally accepted solution is probably the one given by Blaise Pascal. His discussion with Pierre de Fermat was published by the title ‘Traite du Triangle arithmétique, avec quelques autres petits traités sur la même matière’ by Guillaume Desprez in 1665 [10].

The other problem of finding an expected value is the Game of Chance problem. It is also a classical probability theory problem that has been studied deeply over the

years, much more than the problem of points. The problem was described by Cardano in his book 'Liber de Ludo Alea' (Book on Games of Chance) in 1526. The game of chance was next discussed in the book written in 1656 by Christian Huygens and published in 1657 with the title, 'De ratiociniis in aleae ludo' (On the Calculations in Games of Chance). The book remained as the book on mathematical probability for nearly half a century until the book of Jakob Bernoulli, *Ars conjectandi* (Art of Conjecturing) was posthumously published in 1713. Although his contribution to the game of chance with which he began his treatise as a discussion of Huygens' problems was minimal, the treatise is acclaimed as the founding of Mathematical Probability. A more elaborate work on the theory of probability was by Abraham De Moivre in his book 'The Doctrine of Chances' that was published in 1718. De Moivre tackles the problem of the game of chance just the way Bernoulli did, as a part of elaborate problem of expected outcome. A very convincing formula to the problem of probability came from Reverend Thomas Bayes in his book 'An Essay towards solving a Problem in the Doctrine of Chances' that was published in 1763, three years after his death. The Bayes' Theorem which speaks of the probability of an event E happening if a prior event F has happened and is given by the formula $P(E|F) = \frac{P(F|E)P(E)}{P(F)}$. It is the formula to calculate conditional probability commonly used in all fields even today. Pierre-Simon de Laplace is said to have laid the foundation of the classical theory of probability. His book 'Théorie Analytique des Probabilités' (Analytical Theory of Probability), was first published in 1812 and there were later editions to it in 1814, 1820, and 1825 [10, 11].

The next greatest contribution to the theory of probability was a hundred years later by Andrei Markov. Markov extended the results of Bernoulli and developed the calculations for linked probabilities. He came out with the idea of Markov process in 1913. The stochastic matrix or a Markov matrix that describes the Markov chain were also his great contributions [10].

2.2 The Problem of Points

It is the first classical uncertainty problem recorded. The problem is recorded as how will the reward be shared between two players if the game was interrupted after sometime while one person was leading in points. A similar problem can be presented in medical diagnosis. If a patient has a symptom s1, which is indicative of a disease d1 in 60% of the cases or a disease d2 which also exhibits the same symptom s1 in 40% of the cases. The pre-test probability (prior-probability) is 60% for d1 and 40% for d2. So, what should the physician suggest. The answer attempted by Luca Pacioli is to divide the points already got by a player by the number of games that have to be played to win the game. That will give the share of the reward. For example, if player A has 60 points and player B has 40 points, A gets $A/(A+B) = 60/100$ or 60% of the reward. Similarly, player B will get 40% of the reward. If we are to apply the solution to the medical diagnosis problem, then we have to divide the pre-test probability with the sum of the pre-test probabilities. Although this does