Journal of Modern Physics, 2023, 14, 1157-1166
https://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

The General Theory of the Probability

Julio A. Barraza

Division de Ingenierías Civil y Geomática, Facultad de Ingeniería, Universidad Nacional Autónoma de México, Ciudad de México, México
Email: julioantonio86@hotmail.com

How to cite this paper: Barraza, J. A. (2023) The General Theory of the Probability. *Journal of Modern Physics*, **14**, 1157-1166.
https://doi.org/10.4236/jmp.2023.148063

Received: April 1, 2023
Accepted: June 28, 2023
Published: July 1, 2023

Abstract

The probability, in space and time, equations for a single event (experiment) are determined, within a physics approach, using basic concepts in mathematics and physics. The statements, equations and conclusions, offer a better scope for decision-making in several areas of sciences, especially in those where the motion of an object, structure, biological or mechanical body is based on the friction and adherence between surfaces. This scope is different from the probability of an outcome from a coarse "sample space" or the probability of a set of consecutives events. This scope analyzes the forces for a single specific event and includes the variable "time". Finally it is discussed the analysis of the equations for their use in robotics.

Keywords

Probability, Measurable Space

1. Introduction

There are many probabilistic methods used in the different areas of sciences, whose purpose is decision-making, according to the probabilistic conditions. [1] shows an awesome summary if probability we are talking about, presents what probability is, for varied authors and takes a step more forward to unravel the concept and unify the probability theory. Despite of the numerous interpretations, none of these models are wrong, in these models the concept of probability is made under the cognitive state of the author (observation or wide of the sample space, and uncertain or conditional outcome). Moreover, the mindset of the authors in [1] is clear on what is the first step needed to create a probability model "fix what you would calculate as a probability". In the present paper the concept of probability is definite.

2. Scope

"Similar to other branches of mathematics, the development of probability theory from the axioms introduced by Kolmogorov relies only on logical correctness, regardless of its relevance to physical phenomena" [2]. This paper converges more with the phrase "Probability is common sense reduced to calculation" (Laplace), focusing on the variables that make one single specific event possible.

Which are the variables that make it possible a single event to occur? For example, how to calculate the probability that an object falls off by the edge of a table? This event can be considered completely random and the variables and the plights infinite. It is from this specific question that the analyses and following statements arise. The scope implies that a physics approach will be used, because it is intended to define the concept of probability and express it by an equation with the variables that make such event possible. For this, we will begin with a simple analysis in which the variables to consider are minimal or are reduced for practical purposes, subsequently the variables to consider will be increasingly more until all of them are considered.

3. Probability and Occurrence

3.1. Simple Analysis

Before fully start to analyze the main approach, it will begin with a case in game theory, considered here as simple. This case (experiment) consists in calculating the probability of choosing one specific card from a pack of a conventional 52 cards deck. As all the possible results are known (sample space Ω), the calculation of the probability is made dividing 1 by 52 and it is expressed normally in a percentage way, as the following equation indicates.

$$P = \text{outcome}/\text{sample space}(100\%)$$

$$P = 1/52(100\%)$$

$$P = 1.92\%$$

where:

P Probability of choosing a single card.

3.2. Complex Analysis: Main Analysis

One big difference in this analysis is that only considers one result, not other results are considered, therefore, it is not possible to calculate the probability by a fractional arithmetic expression. Neither is considered a set of consecutives events like, several toss of a coin. This analysis focused on the forces that make a single event possible, in the case of a coin toss, will be, in the friction of the air at the time of the toss and the different of the weight of each face of the coin and the surface properties in which the toss will be developed.

In **Figure 1** the drawing of an object is shown, with a weight $\boldsymbol{W}$, over the surface of a table, at a distance D of the edge B of the table. The questions are, can the probability of this event be expressed by an equation? Which are the variables that make it possible for the object to falls off by the edge B of the table?

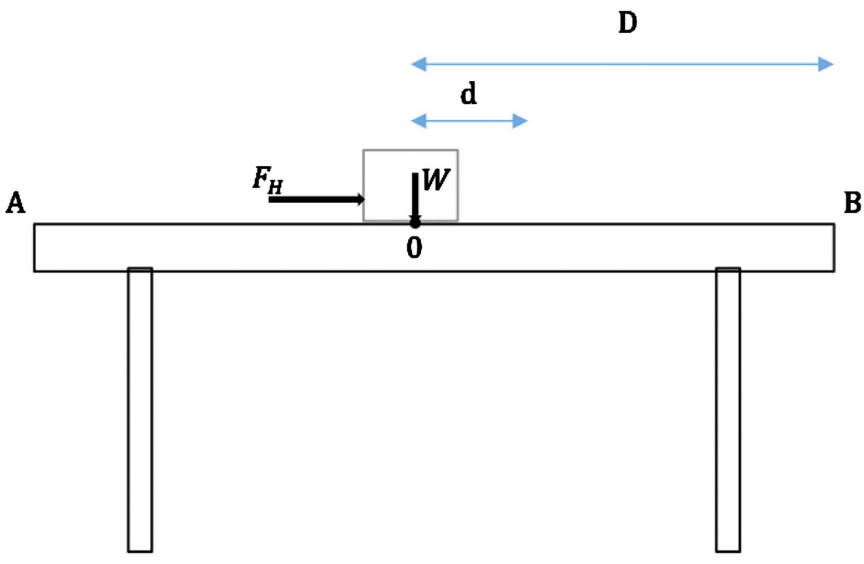

Figure 1. Condition of forces and variables in the probability that an object falls off by the edge of a table.

The first logical answer is that there are forces against the motion of the object and forces positive to the motion; this could be represented by an addition and subtraction of forces. An a clearer way to visualize it will be to pretend that a person exerts a force with his hand in the direction to the edge B, with the intention to move the object over a line between the object and the edge, of which magnitude should be that force to move the object?

To continue with the analysis it has been decided to use the friction model (friction law) developed by C. A. Coulomb in the XVIII Century, this implies that the object and table must remain in contact, which is an important consideration. Nevertheless, the forces, its origins, its manifestations and the different conditions will not be limited in the analyses to come.

Through the experiments developed by Coulomb it was discovered, that, if the relation between the horizontal force, $\boldsymbol{F_H}$, applied to move the object and the limit-resisting force, $\boldsymbol{F_R}$, is greater or equal to 1, the object will start to move [3] [4] [5]. The relation is shown here:

$$F_H / F_R \geq 1 \tag{1}$$

where:

$\boldsymbol{F_H}$ Horizontal force applied to move the object (tangential),

$\boldsymbol{F_R}$ Limit-resisting force.

The limit-resisting force depends on a static coefficient of friction, μ, which varies according to the nature of the surfaces in contact [3] [4] [5] and the orthogonal force to the surface in contact (sliding surface), in this specific case, the Normal force exercised by the weight $\boldsymbol{W}$ of the object, plus the cohesion, as it is shown next:

$$F_R = N\mu + c$$

It is important to mention that the force, $\boldsymbol{F_H}$, as is shown in Figure 1 generate a momentum, the way to calculate the Limit-resisting force is in laboratory with specific procedures for specific materials and for specific conditions of applied forces [3] [4] [5] [6] [7].

If the relation $\boldsymbol{F_H}/\boldsymbol{F_R}$ is greater or equal to 1, the object will start to move to a velocity, $\boldsymbol{v}$, towards the edge B of the table. This relation is very important, because indicates if the event is possible (or probable), in other words, the motion of the object indicates if the event is probable. If this relation remains greater or equal to 1 for a magnitude of time, t, enough for the object to reach the edge B, the object will falls off by the edge of the table, in this case we can talk about a time of occurrence, which can be calculated as the following equation indicates:

$$t = v/D \tag{2}$$

where:

t Time of occurrence.

D Distance between the object and the edge of a table.

$\boldsymbol{v}$ Velocity of the object (depends on $\boldsymbol{F_H}/\boldsymbol{F_R}$).

Analyzing the expressions above, which, for all practical purpose and furthered analysis we will call: expression of probability "1, condition of forces" and "2, time of occurrence", it is valid to state that the probability that the object falls off by the edge B of the table depends on a exerting of forces in time.

Now, The logical premise, which we started, was an addition and subtraction of forces, considering that there are forces against the motion (limit-resisting force) and forces positive to the motion (horizontal tangential force), but we determine a relation of forces, this is because the limit-resisting force is not negative or positive relative to the horizontal axis, it is a force related to the equilibrium, this force will create resistance the same way if the horizontal force is applied to the edge A and that we did not start with the premise of motion as indicator of the probability.

From this, it is important to highlight motion, as an indicator of the probability and from this point on, anything that causes or affects motion will be of interest for us in the next analyses. The difference between this analysis and the analysis with the deck of cards, is that in this analysis the incorporation of the variable time is highly important.

One of the Kolmogorov axioms is the condition of nonnegativity for any event, $P(A) \geq 0$ and the other is the normalization, the probability of the entire sample space Ω is equal to 1, that is $P(\Omega) = 1$. The analysis of this paper only considers one event not a wide sample space and the position of the object can be in any of the caudrants of a fixed axis.

3.3. Probability in Space and Time

Focusing on the time variable, we can consider the two next conditions; the distance between the object and the edge of the table, which could be of great or little magnitude, in this analysis is important the concepts of "measurable space" [8], the other is the relation between the forces that define motion or the velocity of the object. This generate many plights, one of them would be that the object is positioned at a long distance from the edge of the table, in this case, if it is intended that the object falls off by the edge of the table in a short period of time, the relation of forces that define the velocity should be much more than 1, in other words the force applied to move the object must be of great magnitude. If the relation of forces is equal to 1, condition needed for minimal motion, the magnitude of time for the object to falls off by the edge of the table, should be much longer.

Another would be that the object is positioned at a short distance from the edge of the table, in this case the relation between the forces needed to move the object and this falls off by the edge of the table, must be greater or equal to 1 and the magnitude of time needed for this to occur must be also short. See **Figure 2**.

From this analysis, it is valid to state the next definition of probability; the probability that the object falls off by the edge of the table depends on a exerting of forces in space and time, relative to the condition of equilibrium. The probability is very different if the object is located near or far from the edge.

3.4. Multifactorial Analysis

For this analysis, a group of people will be considered, a part of this group is against the motion of the object and the other part is positive to motion. Also we will considering the concept of the table would be an area large enough to make numerous movements and for varied periods of time and concepts like money, communication, technology and anything that could contribute to motion.

Now, the weight of the object will be of such magnitude that results difficult for one person to move. In this case one person could have enough money to pay a group of people to move the object, this makes the event probable in a shorter period of time. If the group of people works one day to move the object a "d" distance toward to the edge of the area, the event is more probable, day-by-day. In the other position, we can consider a group of people against the motion using communication, technology (robots), etc. in opposite direction to the people that try to move the object to the edge B. This discussion can include any kind of forces, known or unknown, understandable or not, still unraveled.

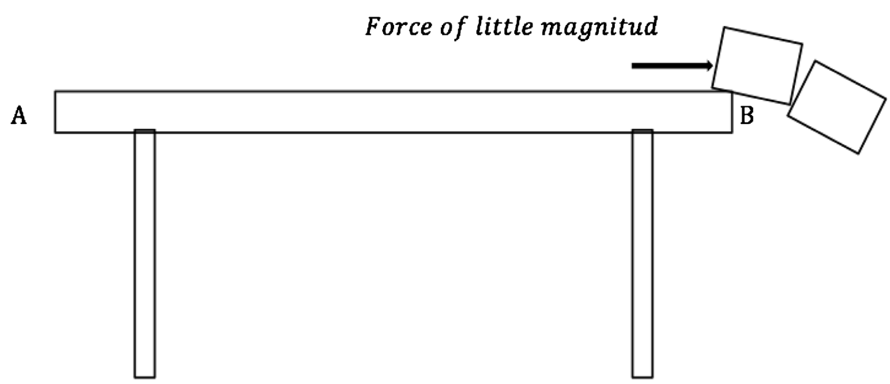

Figure 2. A block falling off a table with a force of little magnitude.

An example would be that a meteorological event produces wind of such magnitude to move the object. In other words, all the factors are considered.

From the arguments exposed in this small discussion and from the analysis developed in previous chapters, it is valid to establish; the probability that the object falls off by the edge B of the area is an exerting of forces (addition and subtraction) in space and time relative to the condition of equilibrium. And the equations of probability "1, condition of forces" and "2, time of occurrence" are established as follows:

$$\left\{\left(\text{Biological } F\right)+\left(\text{Artificial } F\right)+\left(\text{Meteorological } F\right)+\cdots+n\right\}/F_R \geq 1$$

$$\sum F_H / F_R \geq 1 \quad (1)$$

$$t = v/D \quad (2)$$

The mathematical approach that makes this possible is that the forces can be expressed as a sum of several parts [9]. It is valid the operation sum [9] [10] [11] [12] [13]. For example it's not possible to define de operation sum between the conceptual force of money and the friction force or the van der Waals forces, but at the moment when a person exerts a force with his hand over the object is valid the concept of vector space.

It is important to mention that the event considered, could be thought as destructive, once it is intended that the object fall off by the edge of the area. But the same way, the motion of the object can be considered for productive purpose without it falling off by the edge.

3.5. Definition of Money: Trade

Before money the trade was made in species, beast, products, etc. for other products with same value or approximate value [14]. In modern days the money can be trade for almost anything and it is called exchange.

The money can be exchanged for food that provides energy to the people that consume that food and these people can complete certain task with that energy, it can also be exchanged for technology to complete such task in a shorter period of time, like a vehicle to move some material, or a vehicle to pull the object. The money can also be exchanged for technology of communication that allows one person to request to another person complete some task at a remote distance without the need of that person to move to that specific place, or a robot to perform that task.

With correct words, the money is the exchange of the energy in its many manifestations and forms, in space and time, and it is highly important, because it is a factor that can affect the probability and time for an event to occur.

4. Statements

As it was mentioned in the beginning, the main purpose of the probabilistic methods is decision-making based on the probabilistic plight. Most of the methods are focused on the study of a phenomenon and the numbers of times this phenomenon occurs or calculate the probability in the form of a percentage of certain event divided by a total of possible events or a graphical dispersion, minimizing or excluding the variables that make that event possible. Therefore, even thought it is possible to calculate a high probability of rain or pick a card in a game, the event could never occurs, without knowing why? If it is intended to know why?, it must be considered the forces in space and time.

The concept of probability is considered to be a number between 0 and 1, (percentage), the percentage of the faces of a dice in a conditional outcome, the percentage of a coarse sample space with some conditions o properties of the elements of the sample space, but the scope developed here, considering the forces in space and time, allows define correctly the word probability and not just like in the dictionary with the phrase " something that could happen" not definite since Laplace to Kolmogorov and Rocchi and Gurgin, about 300 years and is appropriate for several areas of sciences.

Probability is an exerting of forces in space and time. If the table or any area is set with a grid representing an affine space, all the possible forces and all the possible trajectories form part of The General Theory of the Probability in Space and Time. The chosen distance between the dots of the grid it is also part of the concept of 'measurable space".

5. Discussion for Robotics

Using motion as an indicator of probability and analyzing the forces that make one single event possible and the safety of any object or vehicle, the specific challenges in bioinnspred and biohybrid robots, like; new theory, sensors, actuators (for name a few) that could help for better decision-making, autonomy in any environment and human like perception [15], the use of the equations "1" condition of forces and "2" time of occurrence are suitable for.

The eyes of a human are sensors of light, the ears are sensors of sound, the skin is a sensor of heat and dimension, the tongue and nose are chemical sensors and these are the principles of his perception, and decision-making, even learn to read with 3 of these features, this is expected for the future in robotics [16], learn how to learn, AI [15]. The same way animals develop specific features for his environment.

Most of the robots are bioinspired, this mean, that the motion of these robots is based on the friction between the paws or feet of these robots and the ground (Coulomb Friction Law's). The friction generated between the object and the table is the same friction generated between the shoes of a person and the ground when is walking (friction, momentum of inertia and constant stabilization) by two articulated legs.

In **Figure 3** is shown the position of a robot near to the edge of an area and several lines of trajectories to the edge and several possible forces that could cause those trajectories.

Any robot should be aware of the possibility of damage or self-destruction if

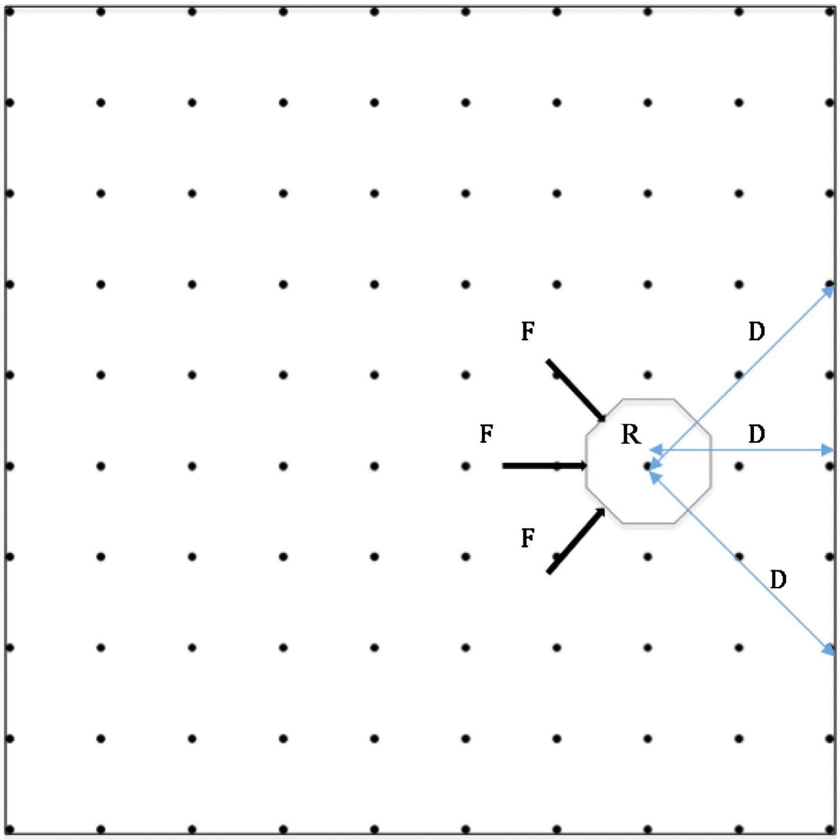

Figure 3. A robot with an octagonal base near to the edge of an area, the area is set with a grid representing an affine space and three different trajectories caused for three different forces.

falls off by the edge of any area with heights next to the edge that could cause damage.

These equations are useful for the development of actuators, the response of the robot should be different if it's located near of far from the edge, just like humans, or living beings and their sensory-motor behavior [16].

The D distance can be adapted for the analysis of the trajectory between a hand of a robot and a glass with water or a vehicle and any edge in any area, with the right sensors according with the chosen measurable space, this is a specific topic for robotic [17].

The forces; capillary tension, friction and adherence between surfaces are widely exposed in the literature, [18] [19] are good examples. These forces are determined for specific procedures, specific materials and specific condition of applied forces. Capillary tension is a concept highly important in this matter because increases the forces of adherence between surfaces. One way to increase the adhesion between surfaces is the presence of cavities on one surface and the presence of low water content in those cavities (not the saturation of those cavities), this could be the case for the design of a robot with human like dimensions, in the opposite way the presence of lubricants between surfaces decrease the friction force.

For the design of smaller robots, the studies of [18] [19] [20] [21] are better-exposed cases, particularly the study of the mechanism of release in gecko´s toes [19].

A similar model to the friction law developed by Coulomb is used in [18] for the analysis of animals and insects that float in water surfaces, it is called Baudoin number $\{Ba = Mg/(\sigma P) >> 1\}$, animals with high Baudoin number (greater than 1) cannot float on water surfaces, these are animals with high mass M. On the contrary insects with low mass M and large perimeter of contact P stay in rest over the surface of water without effort, g is the gravitational acceleration and σ is the surface tension of water. This model is vertical, numbers greater than 1 indicates motion or sinking, numbers lower than 1 indicates equilibrium or rest (not sinking).

6. Conclusion

The concept of the table could represent any area; the curvature of a planet, any path of a vehicle, or the crystal lamina under the scope of a microscope. The use of these equations is especially for "singles events" in any area of sciences where the forces are observable and measurable; but also can be used in more complex analysis and subsequent events. More complex analysis will be unifying the concepts of energy and space. With the correct financial stimulation the study of probability of rain could be well definite using the analysis for a "single event".

Acknowledgements

The author wishes to thanks with overwhelming good feelings to the Dr. Jorge Carrera Bolaños for his advices and the Dr. Juan Espinosa Luna for the support of this article, also thanks Samuel Benítez for his advice in the grammatical revision in some chapters of this article.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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