Scientific Reasoning: A Solution to the Problem of Induction

Wilayat Khan and Habib Ullah

COMSATS Institute of Information Technology,
47040, Wah Cantt, PAKISTAN

***Abstract*—reasoning is an important part of many fields like logic, artificial intelligence, philosophy of science, and so on. Reasoning can either be deductive (deduction) or it can be inductive (induction). The decisions based on induction are very helpful in research but some times they produce uncertain and unreliable results upon which no reliable decision can be made. This is known as the problem of induction. In this paper, after giving deep introduction of induction and deduction, we explain views of different scholars about the problem. These scholars, unfortunately, do not agree at a single point. At the end of this discussion, we come up with a solution to the problem and conclude it. In our solution, we disagree with the strict decision of either to accept or reject induction. Instead, we are in favor to deal induction in a probable manner.**

***Index Terms*—Scientific reasoning, induction, deduction, problem of induction**

I. Introduction

Reasoning or *argumentation* is a process to look for reasons. Reasoning uses arguments which are sets of statements or propositions each consists of *premises* and *conclusion*. Conclusions are derived from the statements (premises). Reasoning can either be *deductive* (deduction) or it can be *inductive* (induction). In an argument, for the assumption that the premises is true and it is impossible that the conclusion is false, the argument is deductive, but if the truth of conclusion is probable then it is inductive argument. One can believe the conclusion if the premises are justified and there is a proper connection between the premises and conclusion of the argument [1]. The connection between the conclusion and the premises is very important, because, otherwise, the reasoning will lead us to a false conclusion. For example, if we say:

Mr. Anwar, a computer scientist, has been teaching us computer science for the last two years.

Therefore

We will become medical doctors.

This does not make sense, because being student of a computer scientist for long period, one may become a computer scientist or engineer, for example, but not, of course, a medical doctor. Induction and deduction are one of the attractive areas of different fields like artificial intelligence, logic and philosophy of science. The problem of induction is among one of the problems being faced which needs concentrative studies. Before going deeper into this problem, we need to define and explain deduction and induction.

II. Deduction

Deductive reasoning or deduction consists of arguments where if the premises are assumed to be true, then it is impossible for the conclusion to be false. Using deduction, there is a formulation of specific conclusion from a general truth [1, 2]. For example:

All the teachers in COMSATS are good researchers; Mr. Anwar is a teacher.

Therefore

Mr. Anwar is a good researcher.

The conclusion drawn using deduction is reliable. One can trust the truth of result (truth preserving). In the example above, if we assume the premises that "*all the teachers in COMSATS are good researcher*" and "*Mr. Anwar is a researcher*" true, then the conclusion drawn "*Mr. Anwar is a good researcher*" based on the premises is always true. It is impossible for this conclusion to be false (assuming the premises is true).

Conclusions are derived from a new idea – an anticipation, a hypothesis, or a theoretical system, using logical deduction. These derived conclusions are compared in themselves and with other statements (if there are any other relevant statements). A logical relation like whether they are equivalent to each other (equivalence), compatible with each other or not (compatibility or incompatibility) and so on, is found.

A theory can be tested either by logical comparison of the conclusions with each other, investigating the logical form of the theory (to find out whether it is empirical or scientific), comparing it with other theories or by testing the theory using the way of empirical applications of the conclusions derived from it. The last test finds out how far the new results or consequences derived from the theory fulfill the demands of practice, no matter whether they are raised by scientific experiments or by practical technological applications. The procedure of testing theory by this way is deductive. Some singular statements or predictions are deduced from the theory with the help of other previously accepted statements. The statements which are not derivable from that theory and which are contradicted by the theory are selected. Now these and other derived statements are compared with the results of practical applications and experiments and a decision is made. If the singular conclusions are verified, that is if they are acceptable, then currently the theory has passed its test. But on the other hand if the conclusions are falsified then the theory from which those conclusions were drawn, is also falsified [4].

III. Induction

As defined in [2, 3, 4], inductive reasoning or induction is the process of reasoning in which it is believed that the premises of an argument support the truth of conclusion, but they don't ensure its truth. It is true even for a good argument, where it is quite possible that there will be false conclusion even if the premise is true. An inference is said to be *inductive inference* if it passes from *singular statements* to *universal statements or theories*. That is to say that induction leads from specific truth to general truth (knowledge expanding). Inductive inferences that we draw from true premises are not 100% reliable, because they may take us to the false result from true premises. Induction takes individual instances and based on those instances, some generalization is made. For example:

Students A, B, and C in the library read.

Based on the above premise, a general conclusion is drawn as following.

All the students in the library read.

Many scholars, historically, like David Hume, Karl Popper and David Miller have discouraged inductive reasoning. They have rejected and disputed its existence.

Inductive reasoning has been divided in two categories based on the strength of its effect; s*trong* induction and *weak* induction [3]. In strong induction the truth of a premise would make the truth of a conclusion probable, but not confirmed. In other words, the truth of a premise can make the conclusion more likely to be true, but it can't guarantee its 100% truth. Consider the argument:

All observed people in COSMATS are literate.

Therefore

All people in COMSATS are literate.

Here we actually induce the general or the universe from the particular or individual. But the conclusion is not certain. The result above may be false. There may be illiterate people in COMSATS. It can be certain if, by some means, the statement 'there is at least one illiterate person in COMSATS' is proved false. This is a proof by *falsification* [5]. *Weak* induction, on the other hand, induce conclusion from the premise, but it is not the correct one. There is no proper link between the premise and the conclusion. Like:

I always put the book on table.

Therefore

All the books are on the table.

You may be in the library studying the Philosophy of Science book and then you put it on the table after reading it. Based on this premise, you draw a conclusion that all the books are on the table just because you have put the book on table. This will lead to generalization based on the certainty of premise. This conclusion will be wrong. This does not make sense to link the conclusion with the premise. The link between the two is very weak. If we use our knowledge from other sources, we can see that the conclusion drawn is wrong. There is no guarantee that all other students put their books on the table in the library after reading. They might return the book to the librarian, who put the books in the book boxes in the library, or the students borrow the books and put it in their bags (instead on table), or they put the book on table outside the library, and so on. Only you put the book on the table but most of the books are already in the vertical cupboards of the library, some are with students for reading, and so on. The conclusions drawn by this way are actually *overgeneralizations* [3].

Scientific laws and theories are actually universal generalization which surpasses the finite number of observations and experiments, on which the theory is based, by a great margin. These theories are confirmed by evidence using induction. This confirmation makes these scientific theories reliable, trustworthy and justifies our belief on theories. If there was no inductive confirmation, science would be just like a 'blind guess'. Induction leads to creative inference where new theories are formulated from the evidence (logic of discovery). After the new theories are formulated, then induction does confirmation by connecting evidence to those theories (logic of justification).

Although inductive reasoning exists everywhere in science but it is philosophically controversial. There are problems to describe the general principles to follow in inductive reasoning (problem of describing) and to justify the inferences or conclusions (problem of induction) [6].

IV. The Problem of Induction

As we mentioned earlier that induction leads to universal or general truth from specific truth. There is no reason or obvious justification to predict universal truth from specific truth. A conclusion drawn in this way may always be false. Now the question arises known as the *problem of induction* [4, 7], is that whether inductive inferences are justified? If yes, under what conditions? Put this question in another way. Is the induction indeed justified? If yes how?

Consider the arguments:

The Philosophy of Science class will start at time 1400.

Because

It has been starting at time 1400 for the last two months.

And the well known Newton's Third Law of motion

For every action there is an opposite and equal reaction.

Can we believe on the conclusions drawn from the premises in the above arguments? Is it possible for scientists to test/have tested each and every action and found and judged the reaction? Also, is it possible for them to verify that the *actions* for all those *reactions* are opposite and equal? Should we trust today that "*the Philosophy of Science class will start at time 1400*"? The scientists may have tested hundreds of actions/reactions where they were equal and in opposite direction. But how can one be sure that the ball will reflect back (in opposite direction) with the same (equal) velocity after we throw it over the wall, considering the factors like speed of air and wall resistance and so on as stated by the theory? We drew conclusion based on induction. We can not use deduction, a logical movement, in all cases to conclude from premises, if there is no *syllogism* to allow us for such movement. Syllogism is a logical argument in which one argument is inferred from two others of a certain form. So relying on induction could be a solution. In induction, just we believe that if a situation holds in all observed cases (tests the scientists carried out in the above example), then that will be true for all other cases (the Newton's Third Law) [7]. Many scholars have different ideas about the problem of induction. We present views of few philosophers in next sections.

A. *David Hume's Views*

According to Hume [2, 6], we can't show that induction is either reliable or reasonable. If some information about initial conditions and rules or principles does not ensure a unique result or solution, then that result or solution is said to be *underdetermined.* Beginning with under determination, David Hume says that our observations do not necessitate our predictions. He further suggests that the principles we use for our inductive inferences are based on the uniformity of nature. Where we believe that the things which are unobserved but are observable are quite similar to the things we have observed. As a result, if we use the concept of uniformity of nature as a basis for the inferences then the conclusion drawn by this way will automatically be justified, if it is shown that the nature is really uniform. But it can't be deduced from what we have observed using uniformity because uniformity itself is based on prediction. To reason to support uniformity, we have the only one option of inductive argument, which in turn will be dependent on uniformity leaving the problem unsolvable. He concludes that the past history of induction can not be used to justify induction. The successes in the past can not justify the success in the future.

B. *Karl Popper's Views*

Karl Popper agrees with Hume. We can relate our example of Newton's Third Law of motion with Karl Popper's view about induction. According to Popper's view, as the scientists have tested hundreds of cases of actions/reactions where the actions and the corresponding reactions were equal and opposite to each other, does not mean that the reaction of an action will be equal to that action and opposite next time as well. There is no way to prove it rationally that the law will be satisfied in next time as well just because it got satisfied many times in the past.

He thinks one can not justify the induction. He supports his arguments by offering a deductive approach *falsification*. In one of his book "Objective Knowledge", Karl Popper presents his views about the problem of induction in the statement [8]:

"I think that I have solved a major philosophy problem: the problem of induction…. This solution has been extremely fruitful, and it has enabled me to solve a good number of other philosophical problems"

In his solution to the problem of induction, he completely rejects induction. Popper in another place addresses the problem of induction with more tight hold [8].

"…. This leads us to the pragmatic problems of induction, which to start with, might formulate thus:

(a) Upon which theory should we rely for practical action, from a rational point of view?

(b) Which theory should we prefer for practical action, from a rational point of view?

My answer to (a) is: from a 'rational' point of view, we should not 'rely' on any theory, for no theory has been shown to be true, or can be shown to be true (or 'reliable').

My answer to (b) is: we should prefer the best tested theory as a basis for action.

In other words, there is no 'absolute reliance'; but since we have to choose, it will be 'rational' to choose the best tested theory. This will be 'rational' in the most obvious sense of *word known to me: the best tested theory is the one which, in light of our critical discussion, appears to be the best so far; and I do not know of anything more 'rational' than a well-conducted critical discussion"*

It is clear from the above discussion that Popper doesn't trust on any theory, because, in his opinion, no one has either shown a theory to be true or can show it to be reliable. He argues that as there is no theory which is reliable and can be trusted, so one should select only "the best tested theory". A theory is considered to be "the best tested so far", only if it is ranked "the best tested theory" by the "critical discussion".

He also doesn't agree with the concept to treat the inductive inference as some degree of "reliability" or of "probability". According to the "probability" concept, the scientific statements can't reach either truth or falsity. They can only get "probable" values. If, according to the principle of induction, the statements don't get the values as "true" and get the label as "probable", then nothing is gained from those scientific statements [2].

C. Wesley C. Salmon's Views

Wesley Salmon [8] doesn't agree with Popper's views about problem of induction. According to Salmon, if a theory is considered to be "the best tested theory so far", then best for what? It can be best either for "theoretical explanation" or for "practical prediction". Salmon argues that as it is "the best tested theory" as a result of "critical discussion" and from some other Popper's statements, so it is "the best tested theory" for "theoretical explanation". He doesn't agree that it can be "the best tested theory" for "practical prediction" because Popper has not provided any reason for that. Salmon mentions two reasons to use induction. According to him, we use induction to predict the future so to remove our intellectual curiosity and to take a decision of some importance about the future events. He finally, reaches his end point about the problem that if we want to make a practical decision then using only deduction is not suitable for the problem of rational prediction. He suggests that it may be possible to remove out the "inductive ingredients" from science, but it would make the science a "bird without wings".

V. Solution to the Problem

According to the Newton's Third Law of motion

For every action there is an opposite and equal reaction.

There are many practical examples and applications based on the truth of this theory. In the gun and missile systems, the gas from the explosion shoots the bullet/missile forwards with force and the whole gun/missile launcher jolts backwards with an equal force in the opposite direction. As a result, the bullet/missile is fired in the forward direction. Similarly, in airplanes and rockets, the gaseous form of the fuel burns inside the engines. The hot exhaust gases come out from the back side with a very high speed and pressure which raises the airplane and rocket in the direction opposite to the evacuation of the fuel.

According to the Popper's view, the scientists tested hundreds of cases of actions/reactions where the actions and the corresponding reactions were equal and opposite of each other. It does not mean that the reaction of an action will be equal to that action and opposite next time as well. There is no way to prove it rationally that the law will be satisfied in next time as well just because it got satisfied many times in the past. In simple words, Popper does not accept Newton's law.

If it is assumed, at least once, that the theory "*for every action there is an opposite and equal reaction*" is wrong. As the systems of airplane, bullets and rockets are based on the truth of the Newton's theory, therefore, it implies that these applications can not be implemented in real life. But wait a minute, we daily see the airplane can fly and the bullets and rockets are fired. It means that the theory is true and the inductive reasoning can not be 'rejected'.

Consider another example of two cricket teams A and B playing a match. According to the past history, team A has won 60%, team B 30% of the total matches and 10% have tied. Who will win the match today? There are three possible answers, A, B or a tie. The true answer can be A as A have own 60% of the matches in the past. The answer is according to the strong induction where the truth of the premise makes the conclusion more likely to be true, but it does not guarantee its 100% truth. This indicates that the inductive reasoning helps us in decision but this decision can not be reliable. The team B may win the match of today which will slightly increase the percentage of winning of team B from 30% or the match may be a tie. It shows the inductive reasoning can neither be 'accepted' (put inside the circle) nor 'rejected' (put outside the circle) with confidence. We believe the border of the circle which demarcates the shaded areas of 'accepted' and 'rejected', is a wide band. We put inductive reasoning 'on' the circle line in between instead of strictly rejecting or accepting. In simple words, we do not 'reject' inductive reasoning. We believe on inductive reasoning in a probable manner.

VI. Conclusions

Inductive reasoning or induction plays a vital role in scientific research, but unluckily the results or conclusions derived using induction are not reliable and they can't be trusted, which leads to the problem of induction. Different scholars have different views about induction. Wesley C. Salmon, favoring induction, thinks that induction is necessary for science both in the case of intellectual curiosity and practical prediction. Karl Popper and David Hume both have concepts against of induction. According to them, there is no reason to rely on the conclusions drawn using induction. Karl Popper is also not in the favor of "probable" concept of inductive conclusion.

There is no single point for all the scholars to arrive at. If we analyze the views of all the philosophers, one can reach to the point that conclusions by induction are not some thing to put outside or inside of a "sharp" boundary using a "demarcation" rule. Induction gives conclusion which may lie on the wide band of border between true and false, giving a probability based conclusion. So, dealing induction in a "probable" manner, unlike the strict rule of "rejecting" or "accepting" induction, is a reasonable solution to the problem which more likely favors the views of Salmon.

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Wilayat Khan earned his B.Sc. in Computer Systems Engineering from the NWFP University of Engineering & Technology, Pakistan in 2007. He completed his MS degree from the Royal Institute of Technology (KTH) Sweden in Information and Communication Systems Security in 2009. In his MS theses, he designed a strong authentication protocol for handheld devices.

Mr. Khan started his carrier in 2009 as a teacher at the Department of Electrical Engineering, COMSATS Institute of IT, Wah Campus, Pakistan. He has published a number of papers on wireless and mobile networks and security in international journals and conference proceedings. His research interests include wireless & mobile networks, energy-efficient protocol design for mobile devices, authentication, web security and smart cards security.

Habib Ullah earned his B.Sc. Computer Systems Engineering from the NWFP University of Engineering & Technology, Pakistan in 2006 and M.Sc. degree in Electronics and Computer Engineering from the Hanyang University, Seoul Korea with a thesis focusing on comparative study: the evaluation of shadow detection methods.

Mr. Habib started teaching in 2009 at the department of Electrical Engineering, COMSATS Institute of IT, Wah Campus, Pakistan. He has various publications focusing on background modeling and shadow detection. His research interests include information security, pattern recognition, behavior modeling and object segmentation etc.