Induction, Traduction, Abduction and Deduction in the Processes of Hypotheses Generation and Justification

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Abstract. *This paper shortly examines the processes of production and justification of hypotheses in formal and non-formal systems. Different points of view on inductive approach are shown. The levels of hypotheses in complex systems are brought in practice. The properties of inductive inference are defined and studied. Interaction between induction, traduction, abduction and deduction in generation and justification of hypotheses are analyzed. It is shown that for modeling these processes it is necessary to develop the formal methodology, which provides the integration of all classes of inference models. Such a methodology has to support synthesis and analysis of hypotheses by means of continuous interaction of corresponded coherent processes of reasoning. Use of multi-agent approach would be reasonable for development of proper computer technology.*

Keywords

Logic, induction, traduction, abduction, deduction, modeling, hypothesis, model, investigation.

1 Introduction

Inductive view on science was classically described by J.S.Mill in his "System of logic" (1843); it presupposes that scientific researches must begin from free and unprejudiced observation of facts, then have to be continued by the inductive formulation of universal laws, which describe these facts, and, finally, to come to the more general conclusions (it is agreed to call them "theories"). But, if to imagine the science as the sequence of infinite attempts of existing hypotheses' refutation and to replace them by another, non-falsifiable statements , it should be naturally to ask, where these hypotheses appear from.

K.Popper [1] follows general view, when rejecting any interest to the so-called "context of discovery" (contrary to "context of justification") — a problem of the origins of scientific knowledge remains in the sphere of psychology or sociology of knowledge — but, nevertheless, he persists that any source of sciential generalization definitely does not represent the induction from separate cases. For him, an induction simply is a myth: the inductive hypotheses are not only illegitimate (as was shown by D. Hume long time ago), but are also impossible.

We cannot make unductive conclusions when starting from some series of observations because at that moment of time, when the choice of certain kind of observations has been made, we already took the certain point of view, and this point of view is a theory itself, no matter how that theory is simple or rough. In other words, "rough" facts do not exist — all they already contain some latent theory. M. Blaug [2] goes further when says that general opinion about induction and deduction - as mutually inversed processes of thinking - is big misapprehension. He argues the necessity to bring into practice new term „adduction“ - as the non-logical operation of “transition“ (the discovery, in the best sense of this word) from the chaos prevailing in real world to intuitive guess or trial hypothesis concerning the factual interrelations between sets of relevant variables.

We take liberty to stand on position which would "reconciled" J.S. Mill and K. Popper.

2 Levels of Inductive Conclusions

It is proposed to consider different levels of hypotheses. Let distinguish, at least, two levels: 1) "what does depend from what" (Popperian conception, in the our opinion) and 2) " how it depends" (position of J.S.Mill, we suppose).

Evidently, intuitive surmises, an experience, the talent of researcher (i.e. the matters lying in sphere of psychology), and, sometimes, also metaphorical or associative conclusions, correspond to the first level. On this level we define a composition of properties which are means by those the object (examined or designed) displayed itself.

Inductive methods of Bacon-Mill and, certainly, methods of probability theory as well as mathematical statistics already correspond to second level. Here we define the structures of dependencies parametrically: which is pattern of certain dependencies. But refutaion of hypotheses generated on the first level are also possible. Furthermore, on the first level it would be reasonable to include "doubtful" (extra, additional) valiables (properties, parameters) specially.

Selected levels correspond to G. Klir's epistemological levels of systems hierarchy [3]. He considers five generalized levels of our knowledge about systems: 0 – *source systems* (describing the basic system properties), 1- *data systems* (matrices of values that correspond to properties of parameters), 2 — *generative systems* (models, rules, laws, formulae etc., which describe the system's framework); 3 — *structured systems* (relations between the models for complex systems) 4 — *metasystems* (relations between the relations are biult below).

Probably, it is not accidently that G. Klir called the bottom level as "zero-level". He does not indicate which properties become the parameters of certain system. For him, probably, these matters refered to the basic axioms. System analysis and general systems theory also do not propose adequate methods. Remark that noted Russian scientist in the field inductive logic, V.Finn, developed and now uses his special method, named in honour of J.S.Mill and also quasi-axiomatic theory for *data systems*, i.e. he considers that *paremeters of system are previously defined*. Methods and aids of Data Mining also apply to data matrices. These technologies are used for the knowledge generation when some preliminary hypothesis about set of parameters that characterizes the process examined or framework studied, is already known. It concerns to all methods based on mathematical stastistics, fir instance, maximum likelyhood and least squares methods, GMDH („Group Method of Data Handling“) and others, because they work with the data matrices.

Thus, logic, mathemathics, system analysis, cybernetics, artificial intelligence and other more or less "formalized" sciences examine generation hypotheses' processes on the second level. All such methods and are able to verify or refute hypotheses of the first level. At present, processes of hypotheses synthesizing on the first level are subject of investigation in philosophy (gnoseology and epistemology), psychology, and to bigger extent — in cognitive science. Therefore it is interesting to investigate how humans generate and justificate hypotheses.

3 How the humans build, justificate and refute hypotheses

Beyond dispute, an analysis of these processes requires the separate deep and thorough investigation. Here we will try to define, from our point of view, only some basic positions. Earlier, one of us already touched these matters in [7].

In order to solve problems of different nature we make, analyze and reject hypotheses (produced both by us and other people). And at that time our thinking do not proceed in inductive, deductive, traductive or abductive manner separately. For instance, the „deductive method“ of Sherlok Holmes contained, *per se,* very few of true deduction — inductive and abductive reasoning prevailed in his conclusions. All such lexical labels were brought in operation by logicians to make classification and formalization of corresponding methods of reasoning. The introducing of one more term "adduction" (see [2]) is proposed by some researchers, but it is necessary to define the proper class of reasoning for this term.

We suppose these four classes of logic would be enough for our analysis. In further studies we shall also consider *retroduction* (almost *abduction*) and *reduction (an explanation of complicated things by more simple ones; simplification or almost analogy)* in the processes of production and justification of hypotheses. Obviously, at present time it is necessary to build the general classificator of existing types of logics and to explore the set of certain formal constructions with subseqent setting the accordance between them and the processes of natural thinking. Artificial intelligence deals with classical and non-classical logic, monotonic and non-monotonic reasoning, deductive and non-deductive conclusions. Here we are interested, in a greater extent, in **certain and plausible kinds of logical inference. Certain** inference is produced by deductive reasoning, whereas the plausible one is generated by all others kinds of reasoning. It is not accidently that any mathematical proof represents the deductive "chain". It also concerns the criminal evidence (see, for instance, a final of nearly every detective novel).All other versions of reasonings are only plausibility. Certainly, the hypothesis is always only plausible. But there are some exceptions. For example, the full (in particular, mathematical) induction.

Earlier it was widely accepted to consider that only inductive conclusions allow to generate a hypothesis. Then C.S.Peirce proved "inconsistency" of the induction in many cases and introduced [6] the notion of abductive conclusion. Moreover, he believed that just this class of reasoning is basic in hypotheses formation . We shall emphasize the main thing, from our point of view, the difference of abduction from induction. By means of abduction the hypothesis is formed as the cause of some (observable) event. There would exist more than one such a cause. More often they (causes) are connected by the operator OR. With the help of induction the generalization of several events is made. These events are binded by operator AND.

From our point of view, traductive conclusions are not less important during process of generation of hypotheses. We shall remind, that *traduction* (from Latin *traductio* - moving) is the inference, where the premises and the conclusions are judgments of identical commonness, that is, the inference goes from knowledge of the certain extent of commonness to new knowledge, but of the same extent of commonness. The *analogy,* which we frequently use both during synthesis of a hypothesis, and in its justification or refutation, is *traductive conclusion* (remind the dialogs of Socrates). Both metaphor and association are versions of the conclusion by analogy. And the power of these versions of conclusions in formation of hypotheses (especially, original) is difficult to overestimate.

Relation of *similarity* lies in the basis of any model . Hence, modeling is an inference by analogy. It is not accidently that the theory of models (and theory of categories) in mathematics, generally deals with morphisms (conformity). In general, it is possible to construct an opposition scale "informal - formal" concerning the similarity relations. A metaphor would correspond to one pole on this scale and mathematical model - to another pole. Certainly, in practice any models can be the basis of hypothesis concerning the process modeled. We shall notice that the data matrix is also the model.

It looks quite obviously that the person during generation of hypotheses uses continuously all versions of available reasoning, dynamically passing from one to another. Thus we not always clearly realize what logical procedures do help us to come to one or another hypothesis and how we prove it. Lawyers often use precedents (analogies) to prove their arguments. Humanitarian scientists give examples, metaphors etc. Remind, how we solve complicated tasks and problems.

4 Properties of hypotheses

Properties of the inductive, abductive, deductive and traductive reasoning were examined earlier in [7]. Here we consider the properties of hypotheses.

It is impossible to take actions for problem solving without some hypothesis. Even in case of evident practical tasks their decision is made on the basis of the previus experience and skills acquisited, which form a preliminary imagination or a pattern (an idea) of possible ways of solving. That is the hypothesis is such an imagination or an idea.

It is necessary to note, that the hypothesis always contain bigger contents and greater explanatory power than data which support hypothesis. As the hypothesis does not concern to individual judgments of experience and always exceeds them in contents, it cannot be proved only on the assumption of data. The empirical data just are able to disprove a hypothesis, but not to verify it. The hypothesis is prejudiced even though it contradict at least one fact. But each new hypothesis, as a rule, does not reject the contents of former hypotheses fully, but uses all rational considerations. The new hypothesis acts basically as perfected previous one (see works [1]).

In order to separate the most credible hypotheses from the initial conjectures some limitations are put upon their formulations:

1. the hypothesis has to be both syntactically right and semantically understandable statement within certain text[2];

2. The hypothesis has to be proved, to some extent, on previos knowledge or, in a case of its complete originality, not to contradict scientific knowledge [3];

3. The hypothesis has to be not only verifiable in principle when the knowledge changes, but also checkable by available methods, i.e. it should comply with development of scientific tools [1].

The restriction mentioned are both necessary and sufficient conditions to qualify a hypothesis as the scientifical utterance, regardless of its truth or falsity in the future.

Scientific (and any other) idea does not start from scratch. In order to submit a hypothesis to consideration, somebody have to relatete it to knowledge existed before; just in that case this hypothesis could be a subject of investigation and further testing. Indeed, such a substantiation is not final - often the different grounds are found for identical hypotheses. But, this fact is only evidence that validity of the hypothesis is a necessary requirement of its acceptability — absence of due validity discredited hypothesis to such a degree, that it cannot remain the point of further discussion.

Thus, during the generation of hypotheses it is necessary to work not only with data, but to use knowledge bases where the experience of different experts from various knowledge domains accumulated, structured and systematized. These knowledge bases have to contain models, which are collected and systematized from previous case studies (both adequate to a problem and "not quite" adequate; see also above, about the third and fourth Klir's levels [3]). Besides, for generation of hypotheses not only inductive reasonings (or methods of mathematical statistics), but also the abduction and the traduction should be used.

5 On modeling hypotheses generation process

Development of such a model is equivalent to creation of the truly universal problem solver or creation of fully artificial intelligence. But sych a target is not set. As usually in computer technologies, we shall allocate resource (information) and procedural components.

Information environment. Any hypothesis is a model. And the context of any model has the great impotnace foer it. We include in context [8] knowledge of model developer, information about object modeled etc.; and all that should reflect these matters in the knowledge base mentioned.

Procedural environment. Here we mention about very special component of intellectual modeling, which V. Finn has named *"Reasoner"*. It is responsible for support of processes of the full life cycle of hypotheses. In the "formalized sciences" it is reasonable to consider separately six classes of the processes connected to the life-cycle: generation of hypotheses, their verification, adjustment, confirmation (substantiation), use and a refutation. In modeling of all these processes the classes of logic reasoning mentioned above are used. Thus, use of multi-agent systems ideology is preferable. Abductive conclusion is carried out by one agent, inductive - by another one, and so on... The "reasoner" plays a role of supervising systems. Basic difference of offered approach from others lies in creation of flexible integrated environment for the complex objects modeling.

For modeling these processes in computer technologies it is necessary to develop the formal methodology, which provides the integration of all classes of inference models. Such a methodology has to support synthesis and analysis of hypotheses by means of continuous interaction of corresponded coherent processes of reasoning.

6 Conclusion

This issue concern the some actual problems of hypotheses generation. Several important aspect of the generation processes are considered. We suppose that deficient attention to the formation and justification hypotheses processes is one of important reason of low efficiency of many computer technologies. The clear understanding of different kinds of the logical inference as well as better vision of fundamental relations between logical, cognitive matters and theoretical grounds of systemological disciplines, we hope, could help to move forward . It seemed to be necessary the broad scentifical (interdicsiplinary) discussion on problems and matters stated in this paper.

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