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Recent Trends in Analysis of Algorithms and Complexity Theory

Hybrid Research: A methodological paradigm for interdisciplinary research

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Abstract: There have been several classifications about the type of research. But considering the fact that most of the research carried out nowadays, is inter-disciplinary in nature, they cannot be classified under any crisp classification. So this necessitates for clear understanding of the methodology to carry out such a research so that there would be proper monitoring and control over the, otherwise meandering course of research. This study is an attempt to give shape to a class of research where the domain of application is management (Academic) and nature of solution is technical. The work highlights the methodology that can be adopted under such circumstance, including the existing paradigms, the available methodological choices and the rationale behind the current methodology.

Keywords: Methodology, research paradigms, extant, empirical, analytical, interpretive.

1. Introduction

At the outset it would be apt to present the methodological paradigms of research**,** the reason being the choice of topics or broad areas being covered in today's research, ranging from Data Mining to Big Data analytics. Whatever may be the focus of study or research the thrust is on DATA and the means and ways to make this data informative, so as to draw patterns, make inferences, take decisions and last but not the least predictive analytics. And the very nature of data is, it crosses discipline or domain barriers. Hence working with data essentially gives rise to a lot of inter-disciplinary study and amalgam of tools and domains of all nature. So it increasingly becomes important to at least have a documented methodology which can act as a beacon to such kind of research. So instead of taking up a particular problem domain and presenting its methodology, this study is an attempt to provide an overview of the methodology required to take up such research where we deal with a myriad of data domains and use tools ranging from linear and goal programming to evolutionary computing and SVM approaches, to name a few. The output can be used as a guide to shape the course of study in such kinds of research. Hence in this study, in the following section of Introduction we present the Methodological paradigms of research. In section 2 we present the importance of research methodology. In section 3 we give the rationale behind the choice of papers for this study and in section 4 we present the methodological choices on the extant list. Section 5deals with the rationale behind the presented methodology and section 6 provides the interpretations. And finally section 7 presents the conclusion.

Before delving into the methodological paradigms of research, it would be appropriate to generically define research. Research is a systematic process of investigating, collecting and analyzing information to increase our knowledge about the phenomenon under study in order to establish facts and reach new conclusions. Here words of paramount importance are ***systematic, increase in knowledge, establish facts and reach new conclusions.*** With the absence of any one of the above a research wouldn't be called a research. But then, from the very beginning how do we know whether new facts will be established, new conclusions will be reached and above all whether it will increase our knowledge or not. Here I would like to quote the great scientist Albert Einstein, who said, "**If we knew what it was we were doing, it would not be called research, would it".** So the uncanny and mysterious aspect is always an inherent part of research, what makes it predictable is the word- *Systematic.*

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Every research is based on some underlying assumption regarding the philosophy that guides the research. But before the beginning it's imperative to know these assumptions, which are in turn based on the Paradigms of Research. Though there are several definitions and meanings attached to the word paradigm, it refers to a Pattern or Model, as per the Oxford dictionary. It was Thomas Kuhn, who first formalized the meaning of Paradigm in research parlance. Kuhn defines a paradigm as "An integrated cluster of substantive concepts, variables and problems, attached with the corresponding methodological approaches and tools…" [1]. In his book THE STRUCTURE OF SCIENTIFIC REVOLUTIONS, Kuhn described scientific paradigm as a pursuit to know what is to be observed and analyzed, the kind of questions required to gather the required information about the phenomenon of study, structuring of these questions, interpretations of the results of the investigation, and the methodology for conducting such a probe . Terre Blanche and Durrheim identified three major dimensions of research – Ontology (What exists in the world), Epistemology (What one knows) and Methodology (How research can be carried out) [2]. Based on these dimensions there are two broad classifications of the methodological paradigms of research – Empirical-Analytical and Interpretive.

The empirical-analytical paradigm research was traditionally known as Positivism. Because some of the assumptions of the positivists were abandoned, the concept was re-coined as Empirical-Analytical. Quantification and Objectivity are key to this paradigm. Here knowledge comes from a systematic testing of hypotheses, experimentation, statistical analysis and inferences in turn guarantying the validity. This paradigm stresses that reality has measurable properties, which are independent of the researcher. In this research pursuit, data is collected from various sources, using various methods.

On the contrary interpretive paradigm is always questioned. The researchers following this paradigm are continually asked to justify their approach and the underlying assumptions, because there is no fixed approach rather it is a characterization of people's experience of the world, their synergy of interactions and the setting or environment in which these interactions take place. Reeves and Hedberg, stressed on the need to put analysis in a context, in this paradigm [5]. Interpretive paradigm does not use any dependant and independent variables to start. The objective is to observe and gather information, then interpret and draw inferences, finally if possible reveal patterns. Interpretive research does not differ from analytical research in terms of the data they deal with; rather differences emerge because of the underlying assumptions.

Below is a table – Table 1 representing the two paradigms along with a third paradigm of enquiry that is based on both the traditional analytical research and the interpretive research [4][6][7].

Table 1: Dimensions of Research paradigms

Research Paradigm	*Ontology*	*Epistemology*	*Methodology*	*Knowledge*
Empirical-Analytical	Reality independent of the social construction. Reality is apprehensible	Validate the findings in terms of true or false, right or wrong	Triangulation from various sources, testing of Hypotheses, validity , reliability	Attempts to establish causal relationships, Knowledge is objective & validated
Interpretive	Multiple social realities exist. Reality can be explored through varying human experience, interactions and meaningful actions	Personal and interactive, reality is understood through interpretation that influence interaction within social contexts	Data is collected through Interviews, reflective sessions, negotiated reports	Knowledge depends on the skills, linguistic and cognitive abilities of the researcher
Critical	Individual realities are shaped by force and power that exist as a part of social phenomena	Findings provide space for both causal and interpretive phenomena	Interpretive as well as Quantitative methods	Knowledge is shaped by socio-economical, ethnical, political values and are crystallized over time

2. Importance of Research Methodology

Any research work or finding is futile, if there is no appropriate systematic approach, on which the work is based. The work lacks a foundation or a framework, which would in some way validate the research. Within these frameworks lie the underlying assumptions which guide the methodology of research. Without an appropriate methodology in place the work is considered to be flawed and the inferences or findings meaningless. Myers defined a Research Method as a strategy to enquire, which starts with underlying assumptions and then moves to more concrete research design and data collection. A methodology is kind of an action plan, which will help us in keeping track and manage deviations. But unfortunately, technical research in contrast to management research does not much emphasize on methodology. Most of the communicated papers do not even have a section referring to the methodology they had adopted. This makes the work ad-hoc and grossly reduces its validity and moreover generalizing or using the findings becomes extremely difficult. The inclusion of a methodology does not rest on the kind of research rather it is a must for every research undertaken. Broadly classifying there are two kinds of research methodology- Quantitative and Qualitative. A quantitative research can be mapped to an Analytical paradigm and Qualitative research can be mapped to the interpretive paradigm. At the outset it would be unfair to tell which method is better, because the effectiveness of a particular method is based on the context, purpose and nature of research. The table no 2 below distinguishes both the methodologies at an abstract level [4][7].

Table 2: Research methodologies

	Quantitative	*Qualitative*
Objective of Research	Establish causal relationships or relationship between variables, which can be measured.	Understand phenomena in natural settings
Research Methods	Questionnaires, surveys, experiments, statistical analysis. Hypotheses to begin with.	Hypotheses is not required to begin, mode of data collection changes with time and design is flexible and dynamic
Researcher	Observer	Observer as well as a participant
Application	Can be universally generalized	Context-based

3. Rationale behind choice of papers

Papers and articles published in different journals and special conferences were searched for. The search method in this case comprised of two different topics. The study in this case is an amalgam of technical and management research.

The solution is technical in nature, the domain of problem is related to academic management and the inference has extended application. So the initial search was focused on technical as well a management research. For this the search was focused on the following e-resources and databases from the accessibility point of view.

- ✓ IEEE Xplore (IEE/IEEE)
- ✓ Open Information Systems Journal
- ✓ Business Source Premier (EBSCO)
- ✓ Journal of Enterprise Information Management
- ✓ Issues in Information Systems
- ✓ Communications of ACM

The articles that were searched for the domain of application were restricted in terms of time period. As there are huge numbers of articles written in the domain of Management, the selection of articles was restricted to the time period of 2005 -2013. The purpose was to limit the number as well get updated and the latest trends and gaps in the specific domain. But for the purpose of selecting articles in the area of technical tools which were to be applied to the problem domain, the search was not restricted to any time period, but was restricted to evolutionary computing as that is our tool for our other related studies. The mode of search was using the key words –research paradigms, qualitative and quantitative research, Human Resource Management, and Evolutionary Techniques. After the initial selection, the abstracts and the conclusions were studied for the final consideration. Based on the abstracts and conclusions, a number of articles were chosen for content analysis. After a thorough content analysis, we chose few articles for final review, based upon which we would progress our study.

4. Methodological choices on extant list

The proposed research does not qualify to fit into any concrete methodological approach like a Quantitative or a Qualitative approach, as the attributes of the proposed study do not exactly map into the attributes of the above mentioned methodologies. Mostly these kind of techno-management research rely on models and techniques. The literature that has been studied do not follow any quantitative or qualitative methodology, rather they follow a meandering course of action which at some turn takes a qualitative approach and at some turn takes a quantitative approach along with some other methods which are exclusive to technical research. So we can call it to be a hybrid approach. The constructs differed largely in each of the papers as the domain of application varied and the tools were of different nature. Most of the studied literatures have collected their data from secondary sources and the available organizational literature and through unstructured interviews with the domain experts. An interpretive approach was followed to organize and analyze the data. Bogdan and Biklen defined qualitative data analysis as “working with the data, organizing them, breaking them into manageable units, coding them synthesizing them and searching for patterns” [3]. Going by this definition the data collection and analysis was mostly qualitative in nature. The process requires in-depth domain knowledge to codify unstructured data. After the data collection and analysis the domain is studied for richer

understanding of the problem under consideration. The understanding could be manifested in terms of a model or a mathematical formulation. After the formulation, a particular studied technique is used which takes the collected and codified data as its input parameter and tries to find different feasible solutions considering the constraints as well. After the solutions are found they are interpreted for their feasibility and some reliability metrics are used for assessing the reliability and validity of the results. Some of the articles have relied on statistical analysis for their interpretations and inferences. As far as the tools are concerned their reliability is based on the literature available and their ultimate usability.

5. Rationale behind methodology

Below we present the research methodology for the proposed study.

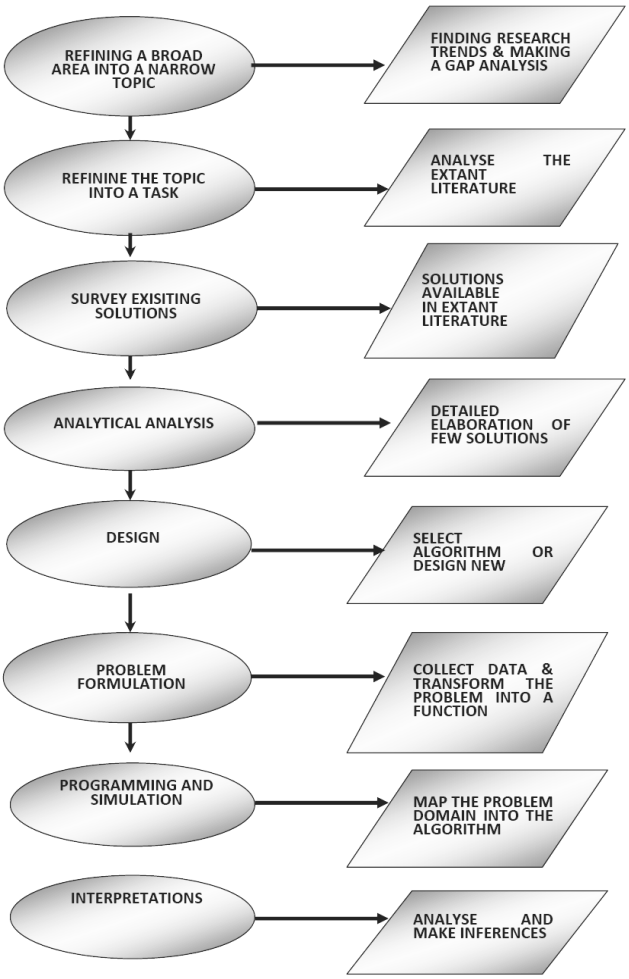

Figure 1: Research Methodology for the proposed study

Here we present the rationale behind the choice of methodology for this study. As is the case with methodologies used in the extant list, it would be worthwhile to go for a Hybrid Approach. Unlike empirical research, this kind of research deals with uncontrolled knowledge representations, algorithms, inference methods and different levels of a-priori information. As far as the domain of application is concerned, it is very context or organization specific. Hence instead of following any specific quantitative or qualitative approach, the study will incorporate approaches based on the understanding of the researcher as the research progresses. Much of the information required for a methodology to be followed will unfold gradually. Hence a model which incorporates the steps rather than the methods would be more useful. In each step based on the available information the subsequent method would be freezed. Apart from the methodology it is important to also present a coherent presentation methodology. Since we have already discussed, the nature of research is Techno-Management, the methodology will incorporate methods from both the areas.

Below in figure 1, we present the flow of our methodology. [2][4][7].

6. Interpretations

Ideally every researcher begins with a broad sense of the area in which the research has to be conducted. The choice of the area could be guided by the researcher's fascination or interest or it could be some underlying problem which the researcher experiences and apprehends in the real world. So the first step would be to make a broad study in the area of research and find the trends and gaps. The gaps would enable us to focus on specific topics.

After finalizing a topic, the next step is to refine the topic into a task, by analyzing the extant literature. But the rationale behind the choice of task is to be provided. The rationale has to be in terms of the significance of the task, meaningful contribution to the problem domain, representative of the problem domain and finally the solution should be feasible.

After arriving at a task, a survey of the existing solutions has to be done from the available literature. This step should aim at generating ideas which would provide improvement over the existing solutions.

Next step is to go for an analytical analysis. Here a few solutions would be selected and compared in terms of their performance, complexity, validity and reliability. In this step various metrics would be required to perform the comparison and apart from the results, the extant literature would be reviewed for assessment.

After completing the Analytical analysis, the next step is design. This is not to be confused with research design, rather it would be more appropriate to refer to it as a solution design. The objective is to select an existing algorithm or formulate a new one. But the rationale should always be based on the following– is the method an improvement over the existing methods, are metrics available to assess the performance of the method, does it require any a-priori knowledge, are there any underlying assumptions, does it heavily rely on a particular domain, and are there any limitations to the method.

Next comes the problem formulation. This step would require extensive data collection regarding the problem under consideration. The data can be collected from secondary sources, available organizational documents and semi-structured and unstructured interviews with the domain experts and other stake-holders. After collecting the data, the objectives and the constraints can be defined, based on which the problem will be formulated in terms of objective functions.

In programming and simulation, the data from the problem domain is mapped into the parameters of the algorithm. Here we have to assess whether the programs performance is predictable, is the program transparent, is it tuned for a particular problem or can it be generalized & does it require any particular kind of validation.

Last but not the least interpretations. In this step we have to generate the results may be in form graphs, charts and scatter plots and make inferences which can be applied as solutions to the problem under study. Here it is important to consider whether the generation of solutions is an interactive approach, where we can adjust parameters and generate new solutions as per our priority. Inferences have to be regarding the time and space complexity, the limitations, intended category of users and pros and cons if any.

7. Conclusion

At the onset it is difficult to categorize these kinds of studies into any particular methodology. But a closer understanding of the problem as it progresses opens avenues for applying the extant methodologies into this research. So the methodology would become crisp only with the advancement of the research to quite a later stage. Adopting a hybrid approach would be quite difficult because each method adopted from the different paradigms would require different approaches and metrics to be validated, and selecting the suitability of a particular approach is of prime importance. But ultimately to conduct the kind of studies discussed in this paper, the hybrid methodology will be apt considering the myriad of features it incorporates from different methodologies.

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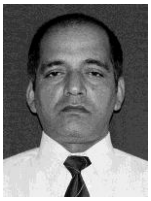

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