Bounded Rationality and Visual Pattern Transmission

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Abstract: - In certain circumstances, humans have to take decisions when time and knowledge is limited. Judgments made under such constrains are considered by cognitive psychology as boundedly rational. The research presented in this paper is rooted in and dedicated to the post-industrial (service-based) society, and aims at: a) revisiting the concept of bounded rationality (BR), in view of its roles in a service-based society; b) substantiating the ambivalence of BR, cognitive limitation and IT guiding principle within the agent-orientation paradigm; c) addressing BR as tool for approximating and measuring quality of provided services, with concern on “JIT” and tailored image transmission. To ensure the qualitative validation soundness, the application field chosen is “Visual pattern recognition”. We present an experimental model of a complex service to be provided (from a holistic perspective, within a user-centred application) by a system with an interface agent for open, dynamic and uncertain environments.

Key-Words: - Bounded rationality, agent orientation, visual pattern, post industrial society, tailored transmission

1 Introduction

For human beings, visual information is vital to recognise, perceive and understand the surrounding world. By the ubiquitous presents of advanced technologies, it is becoming more possible then ever for visual information to be utilized in our daily life. Videoconferences, high definition TV, three dimensional movies, to name just a few, are all demanding video services addressed by complex image compression calculus.[18] The functionality of image compression in visual transmission refers to a process in which the amount of data used to represent an image is reduced to meet a “bit rate” requirement, while the quality of the produced image satisfies a requirement for a certain application and the complexity of computation involved is affordable for the application.

To bridge the gape between huge amount of video data and user’s interest, an understanding of the world in terms of open dynamic heterogeneous uncertain systems must be enabled. Conventional paradigms of sciences starts to be more prone to redefinition of there foundations, understood as scientific knowledge.

In certain circumstances, humans have to take decisions when time and knowledge is limited. Judgments made under such constrains are considered by cognitive psychology as boundedly rational. Conceptually, Bounded Rationality (BR) was endorsed by Herbert Simon, and resisted a half century of scientific history.[16]

Information and Communication Technologies (ICT) experienced in people’s everyday life sets a milestone for an active participation in the society. At a time when information and knowledge are social key drives, we see information as knowledge generating tool, not knowledge itself. Both information and data are closely related yet different concepts. Data represents information and the quantity of data can be measured. In order to exchange knowledge, information remains a fixed form of stabilized knowledge used for transmission. However, information may also be quantitatively measured.

The research presented in this paper is rooted in and dedicated to the post-industrial (service-based) society. Any reference to conceive agents as something else than service-providers is avoided as going against the trends in Computer Science and Information Technology (CSIT).

The approach proposed in these here aims at: a) revisiting the concept of bounded rationality (BR), in view of its roles in a post-industrial (service-based) society; b) substantiating the ambivalence of BR (cognitive limitation and IT guiding principle) within the agent-orientation paradigm, in applications intended to perform in open, dynamic,
and uncertain environments (ODUE); c) addressing BR as tool for approximating and measuring quality of provided services, with concern on “JIT” and tailored image transmission.

To ensure the qualitative validation soundness, the application field chosen is “Visual pattern recognition”. We present an experimental model of a complex service to be provided (from a holistic perspective, within a user-centred application) by a multi agent system with an interface agent for ODUE.

This paper is organized as follows: After an introduction (Section 1) history and related work are summarized (Section 2). The paper tracks to investigate the evolution of BR and focuses on the usefulness as tool in approximation, measurement comparison and benchmark (Section 3). Moreover, this section outlines a service oriented application for “JIT” visual pattern transmission, applying bounded rationality. Conclusions and future work (Section 4) close the paper.

2 Recent history and related work

Our research addresses BR as tool for dealing with complex services provided for/in uncertain and rapidly changing environments. This aspect is emphasized by approaches from different neighbouring fields, presented as history and related work in this section.

Experiments focusing on the implementation of strategies based on BR as key paradigm shift in agent-orientation are summed up in [13][14]. A comprehensive “state of the art” on agent orientation in post industrial society is part of a recent published research report [7].

The paper “Bounded rationality through the filter of the Lisbon objectives”, trials to a better reaction to uncertain and rapidly changing environments as result of ICT implications in the European Council strategy for a sustainable economic growth. “In a society that strives to be progressively technically, technology is becoming a tool for social interaction bridging the strands between online and offline activities, respectively, digital and social behaviour.”[9]

Various applications and theoretical results on behalf of multivariate interpolations applied in process modelling are presented in [3], as transdisciplinary exercise on exploring the connections between approximation theory and algebra.

In multi-agent system consisting of autonomous, cognitive and social agents, we focused on e-learning. To adapt to the dynamic changes in virtual education systems, colony behavioural models (namely wasp and ant) for agents are used. “The model we have introduced allows the assignment of activities in a grant, taking into account the specialization of students, their experience and the complexity of activities already taken. An adaptive method allows students to enter in this system for the first time. The system is changing dynamic, because both the type of activities and the students involved in the system change.”[6][4]

Bounded rationality was investigated and implicitly applied in transdisciplinary niches via “interface agents for transcultural communication” in [1].

An ICT application where BR could be easily applied is described in [5]. It presents a tool for retrieving information with high semantic value and uses a hybrid method with a two level algorithm. Moreover, the paper describes a complex optimization technique on multiple kernels.

3 Rational and approach

3.1 Approximation vs. optimization

Approximation theory has still a major role to play in artificial intelligence, mainly aiming to achieve synergy via blending it with bounded rationality (based on the “just in time” paradigm), not as instrument for uncertain knowledge processing. [2][5]. Hence, the main mathematical mechanism adequate to bounded rationality instead of optimization is approximation. This perspective of our research was investigated in [2]: “Starting from the premise that [...] most non-trivial IT applications are meant for and hosted by open, dynamic, and uncertain environments the paper aims at: a) showing that both bounded rationality and approximation are, at the same time, unavoidable restrictions and valuable means when developing such applications; b) underlining the inadequacy of conventional mathematical methods [...] ; c) outlining an agent-oriented approach to combine synergistically bounded rationality with approximation in modelling.”[2][20]

One convincing example showing that BR sufficed to finding “Just in Time” solution without having an accurate mathematical proof is sketched out in [8]: According to Virgil’s Aeneid the first optimisation problem was the isoperimetric problem (“Dido Problem”) of enclosing the maximum area within a fixed perimeter and was solved in three steps (in IT jargon they could be seen as: system analysis, performance metrics, finding a function
extremum). Although the Greeks knew that the solution is a circle, the first rigorous proof was given only in the 19th century.

Hence, the pre-terminological life of BR shows there intrinsic nature due the vital need to manage situations “Just in time”.

3.2 Bounded Rationality

Ignoring the fact that bounded rationality is “a form of behaviour associated with uncertainty where individuals do not examine every possible option open to them” (www.pestmanagement.co.uk/lib/glossary/glossary_b.shtml), the mathematical tools still recommended for modelling processes taking place in open, heterogeneous, dynamic and uncertain (approximation theory included), are ill-applied when they try to deal with uncertainty. [2]

During its half a century long terminological life, the concept acquired several new connotations as illustrated in [7] including the ambivalence of BR in holistic approaches.

A sub rule of the first Vikings law (i.e. “Be brave and aggressive”[17]) says: “Don’t plan anything in detail”. Thus, it shows two facts: the long standing (lasting) significance of BR and its origins related to “Just in time”, underlining hereby the fact that there is never enough time to optimise in advance.

3.3 Measuring and benchmark
Analysing the meaning of “measuring”, we find that beside “to ascertain the dimensions, quantity, or capacity of” something, it is defined in dictionary (http://www.thefreedictionary.com) moreover as “to estimate by evaluation or comparison” or “to bring into comparison”. Certainly, for our research the last connotations are more relevant. To use comparison we need something to compare to, that established as generally accepted lasting topic ore behaviour.

To be able to evaluate the results of this research, it is essential to have at hand a strong specimen in the application domain of visual pattern recognition. With this regard we investigate the role of a conventional benchmark to measure with. By definition, a benchmark is “(a): a point of reference from which measurements may be made, (b): something that serves as a standard by which others may be measured or judged, (c): a standardized problem or test that serves as a basis for evaluation or comparison (as of computer system performance)” (Merriam-Webster).

With this meaning of the concept, in the application field, conventional benchmarks could be seen as test images generally used in image processing and computer vision. Among others, that reached cult status, Pepper, Baboon (aka. Mandrill), Barbara, Zelda, Airplane, Photographer, Lighthouse, the Lena picture, with his long history, resumed in [7], makes this picture mandatory to be chosen as (lasting) benchmark.

3.4 Experimental model
As a most natural field where BR reveals itself, pattern recognition was chosen as test field, also because there are several widespread benchmark programs enabling validation of the research results.

In this section we present an application that illustrate BR as tool for providing “JIT” service, along with settling the principles upon which experimental models in our further research have to be regarded.

The service offered is based on de idea to transmit only what is asked and needed (part of information - pattern) by the user. From this standpoint, we talk about a tailored transmission, tailored on the users demand, in order to offer “JIT” response.

In the filed of visual information, concepts like transmission and storage are conceptually closely tied together, by means of compression. The purpose of image compression is to represent images with less data in order to save storage costs or transmission time. [18] These techniques are split into lossless or lossy. Both kinds, still transfers the image as whole, unaware of semantic content or user tailored “JIT” transmission, even if lossy compression is usually based on techniques for removing details that humans typically don’t notice.[7]

In essence, the application consists of a dialog between user and a service provider. Whereby, the user is human and the service provider an artificial interface agent. The communication process is a dynamic, self-adjusting and ongoing process, integrating the following steps:

1) user specifies what he needs, related to the chosen thematic ()

2) interface agent notifies if he can provide the requested service and the time he would require to accomplish the request.
(3) user is satisfied and accepts. Otherwise, (meaning the response would take to long in order to be useful) the user may consider reviewing his request in order to get JIT response.

(4) return to (1) (i.e. ask for something else, or change the request granularity).

The internal structure of the application, as depicted in figure 1., reveals a multi agent system sharing a goal and communicate actions and results via the interface agent to the user. Each agent is designed to providing specialized recognition and interpretations features to serve with a complex scene understanding. Moreover, this structure makes it possible to easily integrate further agents. The repository is a set of items about which the multi agent system can provide services. Namely, in our current application it consists of a digital image repository together with metainformation generated and required by each agent’s learning strategy.

The dialog between user and interface agent, as entire process is specialized around a certain thematic, in our case a particular visual pattern.

To show how the system works, we have considered the Lena test image and several user requests asking for patterns understood by the system. Two screen capture of the activity monitor, containing request logs, active users and delivered visual patterns, are represented in figure 2. User monitoring, relevance feedback, initial training sets and collaboration with other agents is supported.

While there are no widely used standards for reporting results of interface agents, a comparing is difficult achieve. On the other hand, so called “learning algorithms” employed in machine learning techniques can undergo standard test based on precision and recall.

In case of interface agents, the measuring of his performance could only be expressed by the agent’s ability of helping a user. Hence, even if user trails do not follow a consistent methodology, they are still best for measuring the usefulness of interface agents.

Psychologists give us general guidelines for measuring, understood as dealing with comparing to lasting behaviour or lasting subject matter. In this light, BR is crucial since it is a psychological, therefore lasting feature.[14] “Humans’ performance on most cognitive tasks are commonly regulated by an underlying latent variable (i.e., “general” intelligence) […]. While “intelligence” in humans is easily recognized, a precise definition of this trait has proven elusive.”[19]

In the evaluation of visual transmission, there are two widely known types for visual quality assessment: objective and subjective. The first one uses electrical precise measurements whereby the second one takes into account human observers. Objective quality assessment is outside the scope of our research, since the user interests on the image are completely disregarded. Subjective visual quality measurement plays an important role in visual communications because it is natural that visual quality is judged by a human user, since he is the beneficiary of the whole service. The idea is simple and old fashioned: human observers are invited to evaluate the visual quality of a set of presented frames and are asked to give some measure of impairment of the pictures, according to a scale rating system for impairment.[18]

In our case, subjective visual quality measurement is implicit, since the user specifies the granularity of the information provided during the whole communication process. With this dialog, the feedback is continuous and validation is JIT and user centred.

As we are trying to provide services according to the “JIT” paradigm, by exploiting users bounded

Figure 1. Overall structure of the application.

Figure 2. User activity monitor.
rationality, the focus is rather on transmission time then on compression efficiency.

In leaking of an accurate measuring tool for services, we made a comparison of the same image processing service delivered once without and once with tailored transmission, and plotted the results in figure 3. In almost all 29 test dialogs, the response time for tailored transmission seemed to be significant faster. Notice that in each case the service provided satisfied the user’s request, i.e. his need of region oriented information.

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Figure 3. Transmission benchmark results.

The results shown in figure 3 are likely to be different for different users, because each dialog terminates just when the provided service has finished, ore in worst case scenario, when the user aborts frustrated.

4 Conclusion

For sustainability in long run, BR becomes vital in conceiving service oriented applications for ODUE since it is a stable/lasting dimension involved.

Real world applications have to be addressed only through tools, inherent of autonomy and uncertainty. We should be aware of the fact that users only seek at certain goals for they are constrained cognitive limitations.

Approaches based largely on right-brain style are encouraged to supplement the limited left-brain algorithmic attempts. In our endeavour, only merging synergistically such approaches (eventually due to non-textual pseudo code for agent-oriented interaction) could insinuate the “holos” of the human brain, where BR comes from.

When referring to visual pattern the focus in so regions of interest, there relation to the whole and semantics. This aspect of a holistic approach is even more important since if some undemanding and very predictable services could be canned – and handed over to machines – no service at all could be assessed (or not even adequately provided) if conceived as decomposable, i.e., reduced artificially to “components”. The system as whole, can’t be deduces from the properties of the elements alone. Hence, programs that can be – and normally are – separated into basic ingredients (e.g., algorithms, objects, DLLs) should be treated cautiously or avoided altogether.

Optimization theory fails due misinterpreting fundamental aspects in modern artificial intelligence: a) uncertainty – agents poses perfect knowledge of there natural environment; b) interaction – agents are placed in parametric environment and do not need to interact with each other, and c) time – agents are not aware of time, since the future is perfectly known and determined for them.

Upcoming challenges in our research and experimental models concern:
- nontextual (maybe even nonverbal) communication in the dialog between the service provider and the end user;
- enquire the applicability of BR as tool for “JIT” service providing not in other fields;
- update partial results with measurements from the experimental model, as well as the evolution of the innovative experimental approach of study;
- Moving the application field from static content – images – to dynamic content – video streams.

Our next research targets should be sustained by focusing on complex services to be provided by bodiless agents in uncertain and rapidly changing environments, via user-centred applications developed from a holistic perspective, following the roadmap from [13].

This paper is part of an ongoing PhD research on Bounded Rationality in Agent orientation, with applications to “Just in time” visual pattern recognition and settles a road map indicator for the thesis it has to serve. The paper finishes groundwork and settles a road map indicator for the thesis it has to serve.

References:


