Machine Understanding and Avoidance of Misunderstanding in Agent-directed Simulation and in Emotional Intelligence

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Abstract: Simulation is being applied in many very important projects and often it is a vitally important infrastructure for them. Several types of computational intelligence techniques have been part of the abilities of simulation. An important aspect of intelligence is the ability to understand. Agent-directed simulation (ADS) is a comprehensive paradigm to cover all aspects of synergy of software agents and simulation and our approach is to develop agents with understanding abilities. After a brief review of ADS, our paradigms of machine understanding is presented. The article clearly indicates types of misunderstandings that might occur. Our research plans are to avoid some of the misunderstandings which could occur and especially to have self-attesting abilities in our applications to document which types of misunderstandings are avoided.

1 INTRODUCTION

Simulation is being applied in many very important projects and often it is a vitally important infrastructure for them. Several types of computational intelligence techniques have been part of the abilities of simulation (Ören, 1995); (Yilmaz and Ören, 2009).

An important aspect of intelligence is the ability to understand. Our research on machine understanding started with understanding of simulation programs (Ören et al., 1990) and evolved to understanding software in general (Ören, 1992), then to understanding systems (Ören, 2000), to agents with ability to understand emotions (Kazemifard et al., 2009), and finally to machine understanding in emotional intelligence simulation (Kazemifard, et al., 2013).

Failure avoidance has been recently intro-duced to advanced simulation studies as a paradigm in addition to validation and veri-fication studies (Ören and Yilmaz 2009).

This article is built on our previous work especially on machine understanding as applied to agents used in simulation and to misunderstanding. However, in this article, we provide three additional machine understanding paradigms in addition to our basic machine understanding paradigm.

After this introduction, we start with a concise review of our view of agent directed simulation which provides a comprehensive framework to consider all aspects of the synergy of software agents and simulation. In section 3, we discuss our four paradigms for machine understanding. Section 4 covers a systemati-zation of most types of misunderstanding appli-cable to machine understanding. Sections 5 covers the conclusions and some of our plans for future research.

2 AGENT-DIRECTED SIMULATION

Agent-Directed Simulation (ADS) is a unifying and comprehensive framework that allows integration of agent and simulation technologies (Ören, 2000). Agents are often considered as model design metaphors in the development of simulations. Yet, this narrow view limits the potential of agents in improving various other dimensions of simulation (Yilmaz and Ören, 2009). To this end, ADS is comprised of three distinct, yet related areas that can be grouped under two categories as follows:

- Simulation for Agents (i.e., agent simulation)

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involves the use of simulation modeling method-methodology and technologies to analyze, design, model, simulate, and test agent systems. This includes, but is not limited to using agents as model design elements (i.e., agent-based modeling).

- Agents for Simulation: (1) Agent-supported simulation involves the use of agents as support facilities to enable computer assistance in simulation-based problem solving (e.g., simulation experiment management); (2) Agent-based simulation, on the other hand, focuses on the use of agents for the generation of model behavior (e.g., simulator coordination, run-time models) in a simulation study as well as agent-initiated simulation.

In agent simulation, agents possess high-level mechanisms that include communication protocols for interaction, task allocation, coordination of actions, and conflict resolution at varying levels of sophistication. Agent-based simulation focuses on the use of agent technology to monitor and generate model behavior. This is similar to the use of Artificial Intelligence techniques for the generation of model behavior (e.g., qualitative simulation and knowledge-based simulation). Agents can provide cognitive architectures that allow reasoning and planning and serve as run-time models of simulation model behavior management such as dynamic model updating and symbiotic simulation. That is, context-awareness of intelligent agents can facilitate simulator coordination, where runtime decisions for model staging and updating takes place to facilitate dynamic composability. On the other hand, agent-supported simulation enables the use of agents to support simulations as well as simulation studies by enhancing cognitive capabilities in problem specification, simulation experiment management, and behavior analysis.

Often, agent-supported simulation is used for the following purposes (Yilmaz and Ören, 2009):

- To provide computer assistance for frontend and/or backend interface functions;
- to process elements of a simulation study symbolically (for example, for consistency checks and built-in reliability); and
- to provide cognitive abilities to the elements of a simulation study, such as learning or understanding abilities.

3 MACHINE UNDERSTANDING

In the study of natural phenomena, the role of simulation is often cited as "to gain insight" which is another way of expressing "to under-stand." Understanding is one of the important philosophical topics. From a pragmatic point of view, it has a broad application potential in many computerized studies including program understanding, machine vision, fault detection based on machine vision as well as situation awareness and assessment. Therefore, systematic studies of the elements, structures, architectures, and scope of applications of com-puterized understanding systems as well as the characteristics of the results (or products) of understanding processes are warranted.

Dictionary definitions of "to understand" include the following: to seize the meaning of, to accept as a fact, to believe, to be thoroughly acquainted with, to form a reasoned judgment concerning something, to have the power of seizing meanings, forming reasoned judgments, to appreciate and sympathize with, to tolerate, and to possess a passive knowledge of a language.

For machine understanding, or computerized understanding, we aim a limited scope as was expressed in a previous publication: "We say that a system 'knows about' a class of objects, or relations, if it has an internal relation for the class which enables it to operate on objects in this class and to communicate with others about such operations. Thus, if a system knows about X, a class of objects or relations on objects, it is able to use an (internal) representation of the class in at least the following ways: receive information about the class, generate elements in the class, recognize members of the class and discriminate them from other class members, answer questions about the class, and take into account information about changes in the class members" (Zeigler 1986)." (Ören, 2000). For additional clarification of understanding and its philosophical roots see Ören (2000).

3.1 Machine Understanding: Basic Paradigm

As seen in Figure 1, an understanding system requires the provision of a meta-model, the perception of the source in terms of the elements and constrains depicted in the meta-model, and an analyser that allows mapping of the perceived elements to constructs of the meta-model. In this context, a model is an abstraction of phenomena or system, whereas a

meta-model provides an abstraction of the properties of the model itself. A model conforms to its meta-model in the way that a computer program conforms to the grammar of the programming language in which it is developed.

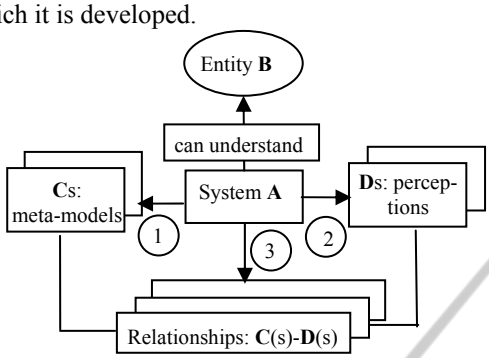

Figure 1: Machine understanding – Basic paradigm.

A system **A** can understand an entity **B** (**E**ntity, **R**elation, **A**ttributes) if and only if three conditions are satisfied (Ören et al., 2007):

- **A** can access **C**, a meta-model of Bs. (C is the meta-level knowledge of **A** about **B**s.) The meta-model can be unique or multiple, fixed, evolvable, replaceable, or functionally equivalent (similar but not identical) to another one. In the basic paradigm, we assume that the meta-model is unique and fixed, i.e., is non-evolvable and non replaceable.
- **A** can analyze and perceive **B** to generate **D**. **(D** is a perception of **B** by **A** with respect to **C**.)
- **A** can map relationships between **C** and **D** for existing and non-existing features in **C** and/or **D** to generate result (or product) of understanding process.

As shown in Figure 2, a functional decomposition reveals that an understanding system has a meta-model, an analyzer, and an evaluator. The meta-model stores knowledge about **B**s. The analyzer analyzes inputs with respect to **C** to produce a perception of **B**. The evaluator can compare the perception of **B** with the meta-model to provide additional information about **B**, such as its non-observable characteristics and how this instance of **B** relates to other **B**s. The product of the understanding process has the following characteristics:

- It depends on the understanding system; that is, another understanding system may have a different understanding of the same entity.
- For a system **A**, understanding depends on: (1) its meta-model, (2) its analyzer, and (3) its evaluator; that is, with a different meta-model, analyzer, or evaluator, the understanding may differ.

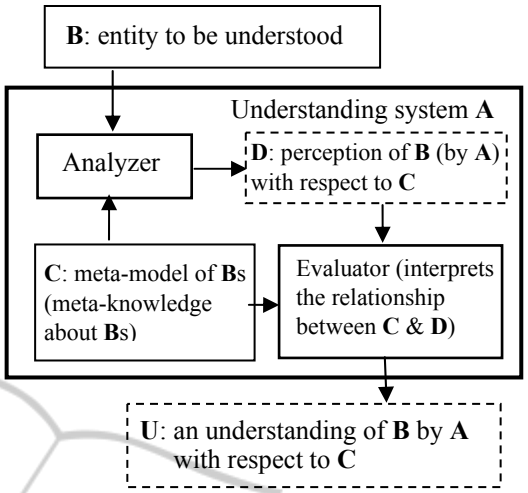

Figure 2: Functional decomposition of an under-standing system (Arrows indicate information flow).

3.2 Machine Understanding: Extended Paradigms

The basic paradigm of understanding can be extended three ways to (1) rich understanding, (2) explortory understanding, and (3) theory-based understanding. As will be clarified in the sequel, the four metaphors for machine under-standing have the following characteristics: *Basic paradigm of understanding*: system has background knowledge (i.e., meta-knowledge) to understand. *Rich understanding*: All or some of the understanding elements may have more than one version. *Exploratory understanding*: Background knowledge (meta-model) has to be found or developed to process the perception. *Theory-based understanding*: A theory (or theoretical model) if formulated without any observation; then technology has to be developed for observation of phenomena. Once the phenomena are observed (perceived) they can confirm the theory which in turn is used to explain the phenomena.

3.2.1 Rich Understanding Paradigm

A model of rich understanding is represented in Figure 3. The difference of basic model of understanding and rich understanding stems from the following:

- There can be more than on meta-model in rich understanding – some may focus on different aspects or may have different resolutions.
- There can be more than on perception of the entity to be understood.
- There can be different interpretations of the perception(s) with respect to meta-model(s).

The total number of understandings may be the Cartesian product of the meta-model(s), perception(s) and interpretations. Rich understanding can allow multi-understanding and switchable understanding.

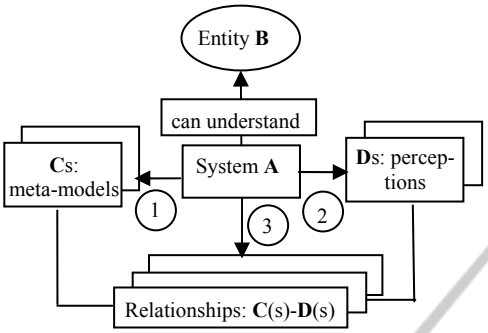

Figure 3: Rich understanding.

3.2.2 Exploratory Understanding Paradigm

Exploratory understanding process (see Figure 4) starts with a perception **D**. Formulation of basic knowledge to interpret perception **D** requires

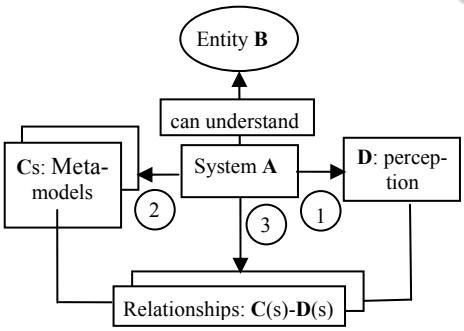

Figure 4: Exploratory understanding.

meta-knowledge to be formulated and/or to be found. This would require formulation and testing of hypotheses. In exploratory understanding, changing the point of view may be very useful to understand the phenomenon or the entity.

3.2.3 Theory-based Understanding Paradigm

Theory-based understanding starts with a hypothesis (or theory); then necessary technology would be developed to perceive (detect) relevant phenomena that would be tested later. A well known example is the gravitational waves (ripples of spacetime caused by events such as colliding neutron stars and merging black holes) which were predicted in 1916 by Einstein based on his theory of general relativity. Still technology to detect gravitational waves is not available.

As another example, in nuclear physics, several models to explain elementary particles have been developed over the years; this exemplifies the existence of several meta-models. Pictorial representation of theory-based understanding would be similar to Figure 3 representing rich understanding.

3.3 Machine Understanding of Emotions: Emotional Intelligence Simulation

According to the theory of emotional intelligence (Mayer and Salovey, 1997), four psychological abilities that enable humans to relate emotionally to one another are: (1) emotion perception, (2) thought facilitation using emotions, (3) emotion understanding, and (4) emotion management. The ability to understand emotions is desirable in intelligent agents (Dias and Paiva, 2009), (Kazemifard et al., 2009), (Kazemifard et al., 2012).

"Emotion understanding is a cognitive activity of making inferences using knowledge about emotions about why an agent is in an emotional state (e.g., unfair treatment makes an individual angry) and which actions are associated with the emotional state (e.g., an angry individual attacks others)" (Kazemifard et al., 2013).

A functional decomposition of our emotion understanding framework –which is an extension of our basic machine understanding paradigm– is depicted in Figure 5.

Our emotion understanding framework consists of four elements (Kazemifard et al., 2013):

- a *meta-model* or knowledge about agents and emotions. It consists of an episodic memory to store observed details of experienced events and a semantic memory to store general knowledge about emotions, such as their similarities and relationships among emotions and experiences in episodic memory. The semantic memory includes semantic graphs to represent knowledge about past emotional experience(s).
- a *perceptor* (or analyzer) to perceive agents and emotions. It assigns similar agents to types and perceives the emotional states of agents.
- an *evaluator* of the perceived agent and the emotion(s) with respect to the meta-knowledge, that is the states of the episodic and semantic memories.
- a *memory modulator* to update meta-model based on observed emotional reactions of agents to act ions.

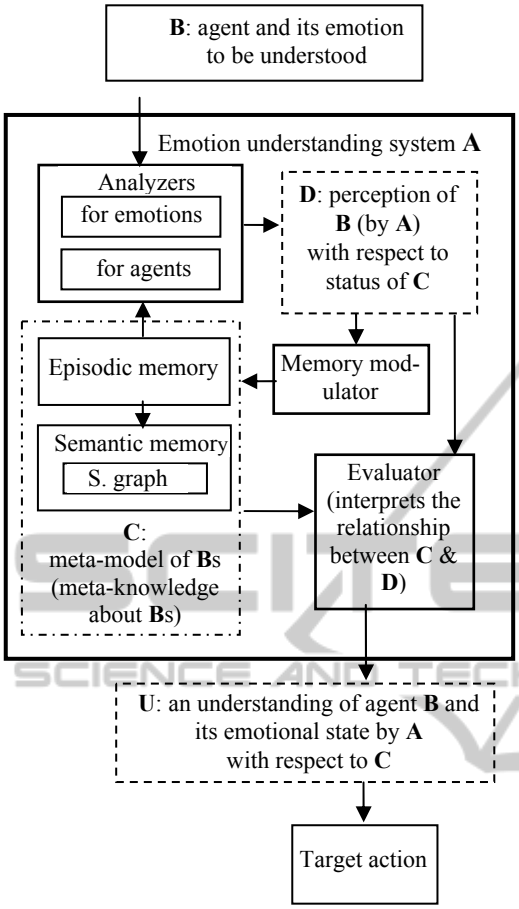

Figure 5: Functional decomposition of the framework of emotion understanding (Kazemifard et al., 2013).

4 MISUNDERSTANDING

There are three possibilities for the outcome of an understanding system,: (1) the system can provide an understanding of the entity or phenomenon, (2) the system cannot understanding it and can or cannot declare its inability to understand, and (3) the system provides a flawed understanding, i.e., it misunderstands the entity or phenomenon and does not warn the (human or another agent) user about its shortcoming(s). Failures in understanding have been first elaborated by Ören and Yilmaz (2011).

Before starting to develop and implement misunderstanding avoidance algorithms, a systematic approach to study causes of misunderstanding would be very useful. This is the aim in this article.

As depicted in Figure 6, there are two main groups of sources for an understanding system not to function properly. They are inability to understanding and filters causing misunderstanding.

Failures in understanding have been first elaborated by Ören and Yilmaz (2011). In this article, we further discriminate two sources of filters, namely internal or self-imposed filters and externally imposed filters for context, biases, and fallacies. However, externally imposed filters are not elaborated extensively. Furthermore, in this article, our basic machine understanding paradigm has also been extended with three other machine understanding paradigms.

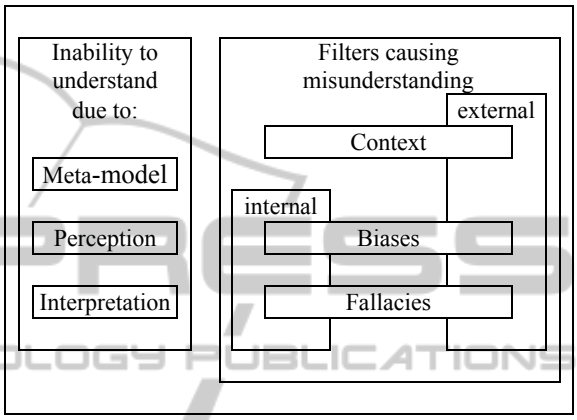

Figure 6. Inabilities and filters that can induce misunderstanding.

4.1 Inabilities to Understand Properly

Inabilities to understanding properly may depend on the meta-model, perception, and interpretation of the perception with respect to meta-model.

4.1.1 Misunderstanding Due to Meta-model

In the sequel, misunderstandings due to meta-model are elaborated on for the basic understanding paradigm, rich understanding, exploratory understanding; and theory-based understanding as well as with respect to the memories used in emotional intelligence. Misunderstanding based on meta-model is *knowledge-deficient misunderstanding*.

4.1.1.1 In Basic Understanding Paradigm

Misunderstanding due to meta-model may be one of the four types:

- not having necessary knowledge (uninformed system),
- not having necessary knowledge of proper resolution (superficially informed system) [*superficial understanding*],
- use of erroneous, incomplete, inconsistent, irrelevant, or corrupt meta-model (ill-

informed/misinformed system) [*ill-informed understanding*] [*misinformed understanding*];
- deliberately applying wrong meta-model (dogmatic point of view). [This type of dogmatic understand can be called meta-model induced *dogmatic understanding.*]

4.1.1.2 In Rich Understanding Paradigm

Misunderstanding may be due to:
- limited knowledge base (lack of additional meta model(s) [*knowledge-deficient misunderstanding*],
- inability to switch to other meta-model(s).

4.1.1.3 In Exploratory Understanding Paradigm

Misunderstanding may be due to:
- non existence of pertinent meta-model,
- inability to find a pertinent meta-model,
- inability to formulate needed hypotheses about meta-models and to test them,
- inability to adopt a different perspective [*misunderstanding due to rigid perspective*].

4.1.1.4 In Theory-based Understanding Paradigm

Lack of understanding may be due to:
- lack of appropriate theory or paradigm,
- non acceptance of appropriate theory or paradigm [*theory-induced lack of understanding*].

4.1.2 Misunderstanding Due to Perception

What cannot be perceived may normally not be understood. Exception is the case of theory-based understanding where theoretical knowledge precedes experimental validation. Misunderstanding based on perception is *perception-deficient misunderstanding*.

4.1.2.1 In Basic Understanding Paradigm

Some sources of problems for misunderstanding due to perception (lack of perception, misperception) are:
- lack of appropriate ability to perceive [*inability to perceive*],
- inability to discriminate [*perceptual confusion*],
- focus on an irrelevant aspect (domain, nature, scope, granularity, modality) [*irrelevant perception*],
- inability to discern goal(s) behind action(s) [*superficial perception*],
- hallucination in the absence of stimulus.
- "The halo effect is a type of cognitive bias in which our overall impression of a person influences how we feel and think about his or her character" (Cherry). Hence, halo effect may cause *inappropriate* and *false perception*; therefore may cause misunderstand.

Perception component of an understanding system should be able to discriminate deception [*deception-induced misunderstanding*].

4.1.2.2 In Rich Understanding Paradigm

Misunderstanding may be due to:
- inability to perceive reality from different perspectives. [*Tunnel vision understanding* is only one way to perceive and interpret; which is not the appropriate way].

Hence, the following types of misunderstandings can be distinguished: *meta-model focused dogmatic understanding*, *perception focused dogmatic understanding*, and *interpretation focused dogmatic understanding*.

4.1.2.3 In Exploratory Understanding Paradigm

Misunderstanding may be due to misperception [*misperception-induced misunderstanding*].

4.1.2.4 In Theory-based Understanding Paradigm

Misunderstanding may be due to instrumentation error. An example is the claim made in early 2012 that "particles can travel faster than the speed of light" as physicists operating the Large Hadron Collider at the CERN laboratory claimed before detecting a bad connection which invalidated the claim [*instrumentation-induced misunderstanding*].

4.1.3 Misunderstanding Due to Misinterpretation

Inappropriate pairing of meta-model(s) and perception(s) may lead to misunderstanding. Misinterpretations may be done unwillingly or willingly. Misunderstanding based on interpretation is *interpretation-deficient misunderstanding*.

4.1.3.1 In Basic Understanding Paradigm

Misinterpretation is a source of misunderstanding and may be due to:
- lack of pertinent knowledge processing ability in interpretation,

- misinterpretation of motivation [*misunderstanding due to misinterpretation of motivation*],
- *illusion* which is a misinterpretation of a true sensation, and
- schizophrenic understanding which –as an aberration– leads to misinterpretations of reality.

4.1.3.2 In Rich Understanding Paradigm

Misunderstanding may be due to:
- lack of appropriate meta-model(s) [*knowledge-deficient misunderstanding*],
- inability to access appropriate meta-model,
- inability to use and to pair relevant perception and relevant meta-model (misinterpretation).

4.1.3.3 In Exploratory Understanding Paradigm

Misunderstanding may stem from the following facts:
- there is not yet an appropriate meta-model as a basis for evaluation of the perception,
- the granularities of the perception and the meta-model may not match.

4.1.3.4 In Theory-based Understanding Paradigm

Lack of interpretation or misinterpretation may be due to the following facts:
- theory was wrong and
- technology is not yet ripe to observe with needed precision.

4.1.4 Misunderstanding in Emotional Intelligence

Emotions may have contradictory manifestations. For example, the behaviour of an athlete crying after winning a match, may be due to his emotional status and distress while he is extremely joyful.

The contents and/or misinterpretations of the two types of memories involved in emotional intelligence can also be source of misunderstandings. For example, strong past psychological experiences as coded in the episodic memory may cause unbalanced behaviour.

The other causes of misunderstanding in emotional intelligence are, as seen in section 4.1 (inabilities to understand properly) and as discussed in section 4.2 (filters affecting misunderstanding).

4.2 Filters Affecting Misunderstanding

Three types of filters such as context, biases, and fallacies may affect understanding and cause misunderstanding. Filters can be internal or imposed externally.

4.2.1 Context in Misunderstanding

Perception and/or interpretation in an improper context can be source of misunderstanding [*context-induced misunderstanding*]. Hence, one can identify: *context-sensitive understanding*, *context-insensitive understanding*, and *double standards in understanding*. Context-dependent understanding would require specification of the context. It would be desirable to have *context-aware understanding*. The types of misunderstandings are *context unaware misunderstanding* and *context-dependent misunderstanding*.

4.2.2 Biases

Several types of biases such as group biases, cultural biases, cognitive biases, emotive biases, personality biases as well as effects of dysrationalia and irrationality affect quality of understanding. Biases may lead to *biased understanding* which may be *erroneous understanding, incomplete understanding, inconsistent understanding* and *irrelevant understanding.*

4.2.2.1 Group Bias in Misunderstanding

The group can be limited by a family, company, institution, region, nation, interest, affinity, and/or religion. A group member may have tunnel vision which might affect understanding process [*tunnel-vision dogmatic understanding*]. Sometimes members may be instructed and even be indoctrinated about a certain way of understanding. At extreme cases, understanding can be blocked to lead to *blocked understanding*.

4.2.2.2 Cultural Bias in Misunderstanding

Values and symbols differ for various cultures; hence a same entity may be interpreted differently based on the cultural background to lead *culture-induced misunderstanding*.

4.2.2.3 Cognitive Bias in Misunderstanding

Cognitive bias is a "common tendency to acquire and process information by filtering it through one's own likes, dislikes, and experiences. [*cognitive bias-*

induced misunderstanding]

"Dunning-Kruger effect "*those with limited knowledge in a domain*: (1) they reach mistaken conclusions and make errors, but (2) their incompetence robs them of the ability to realize it." "*High cognitive complexity individuals* differ from low cognitive complexity individuals not only in knowledge processing abilities in general but in understanding, in particular.

4.2.2.4 Emotive Bias in Misunderstanding

Certain types of emotions affect reasoning abilities to cause misunderstanding [*emotive bias-induced misunderstanding, emotion-induced misunderstanding*]. For example, anger negatively affects reasoning, hence understanding ability. Effect of anger in misunderstanding leads to *anger-induced misunderstanding*. Joy may lead to euphoria which in turn may affect understanding [*joy-induced misunderstanding*].

4.2.2.5 Personality Bias in Misunderstanding

Some personality types are prone to anger; hence their understanding ability can easily be affected to lead misunderstanding [*personality-induced misunderstanding*].

4.2.2.6 Effects of Dysrationalia in Misunderstanding

Dysrationalia is the inability to think and behave rationally despite adequate intelligence (Stanovitch, 1993). It affects ability to understand properly [*dysrationalia-induced misunder-standing*].

4.2.2.7 Effects of Irrationality in Misunderstanding

Irrationality may have two types of effects in misunderstanding (Ariely, 2008) [*irrationality-induced misunderstanding*]:

- lack of ability to understand properly and
- ability to distort understanding of others to cause *distorted understanding*.

4.2.3 Fallacies in Misunderstanding

Fallacy is misconception resulting from incorrect reasoning. A logical fallacy is an element of an argument that is flawed, essentially rendering invalid the line of reasoning, if not the entire argument. Fallacies in *information distortion* as well as *deliberate misperception* and *misinterpretation* are sources of misunderstanding [*fallacy-based misunderstanding*]. They may exist as deliberate use of unfit metamodel in understanding. Two categories of fallacies are paralogism and sophism.

4.2.3.1 Paralogism in Misunderstanding

Paralogism is *unintentional use of* invalid argument in reasoning. It causes misunderstanding due to misperception, mis-interpretation, and/or mis-justification of background knowledge (meta-model) [*paralogism-based misunderstanding*].

4.2.3.2 Sophism in Misunderstanding

Sophism is *deliberately* using invalid argument displaying ingenuity in reasoning in the hope of deceiving someone. Some recent techniques in lie detection in text analysis can also be used to detect sources of attempt to misguide in understanding.

Misunderstandings due to fallacies can be *deliberate misunderstanding* (*giving the illusion of not understanding) and induced misunderstanding*. Data and evidences may be tempered or doctored by the entity which attempts to understand and/or by an outside agent. The individuals (or their representatives, such as software agents) need to notice that their understanding is being tempered [*doctored or tempered-evidence-based misunderstanding*]. Hence, recognizing why a reality is presented in a certain way is helpful not to be trapped in misunderstanding.

A type of misunderstanding is *mutual misunderstanding*. Avoiding mutual misunderstanding is very important to find reconciliatory solutions at different levels of relationships.

4.3 Documentation of Understanding

It would be very desirable for an understanding system to be able to document its abilities and limitations. In this way, a user (human or another agent) can have an informed trust to the results of an understanding system. Based on the systematization used in this article, this type of documentation may include the following:

- Meta-model(s) available and used
- Perception(s)
- Interpretation(s)
- Contents of episodic and semantic memories
- Types and contents of filters used.

A challenging situation in understanding is the case when an understanding system does not have any knowledge (or meta-model) about the entities it is

asked or required to understand. In this case, the system would need to search and get appropriate background knowledge and meta-model(s) and/or be able to formulate and test hypotheses to formulate a meta-model.

5 CONCLUSIONS

This article is a sequel to our joint work on multi-understanding especially applied to understand human behavior and failure avoidance in simulation studies. On understanding, we expanded our basic multi-understanding paradigm and continue to systematize our exploration of sources of misunderstanding.

We plan to implement some cases of misunderstanding to avoid misunderstanding in agent simulation of human behavior and especially in emotional intelligence simulation.

Another line of research we plan to continue is to realize *context-aware agents* for advanced simulation studies. Context aware agents may also be useful in other applications.

In both cases, we will attempt to develop software agents capable to attest their limits of understanding by generating proper detailed documentation of their limits of understanding.

For human misunderstanding, the books by Heyman (2012) and Young (1999) may be useful. In addition to them, the book by Herman and Chomsky (1988) would be useful for external distortions of understandings [*distortion-induced misunderstanding*].

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