ACSIJ Advances in Computer Science: an International Journal, Vol. 2, Issue 5, No.6 , November 2013
ISSN : 2322-5157
www.ACSIJ.org

Text Mining and Image Anomaly Explanation with Machine Consciousness

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Abstract

In the present paper a series of implemented computer systems of information extraction for question answering that generate explanations of this extraction from text and image are presented. These computer generated explanations of the performance of a computer system may function as a criterion of the exhibition of Machine Consciousness. Additionally the systems presented in the present paper may facilitate their communication with their users. Such communication is very useful for building the confidence of a user to a computer system. The main information extraction method used by the systems described here is the one based on a finite state automaton. Following the presentation of systems that have been implemented by our group for various text bases a novel development is reported concerning the explanation of image anomalies. The presentation of our novel work is helped by an example of anomaly detection and explanation in modern paintings.

Keywords: *Machine Consciousness, Cubism, image understanding, explanation***.**

1. Introduction

Machine Consciousness (MC) research has at least two distinct goals:

1. Simulation of Human Consciousness
2. Implementation of computer systems for tasks requiring MC that are INSPIRED from the Human Consciousness phenomenon

Simulation of Human Consciousness requires access to reproducible experimental results with human subjects that we do not have access to. Therefore we are pursuing research in MC aiming at the implementation of systems for the execution of tasks inspired by their execution by humans. A special case of MC is Machine Introspection of reasoning on which the generation of explanations is based. A set of such tasks that may require MC are:

1. Deductive question answering from texts generating together with the answers explanations in natural language.
2. Computer aided instruction using question answering from texts and generation of tutorial explanations in natural language.
3. Software systems supporting their debugging with explanations of their failures or anomalous behaviour.
4. Artificial vision based on image understanding by reasoning.

The detection of image anomalies is a subject of recent interest in the Artificial Vision community [3],[4],[5]. The novelty of the work presented here is based on anomaly explanation generation mechanism based on a vector state FSA as detailed below.

In [6] explanatory reasoning with images is reported but based on description logics which is a different approach from the one presented here that is based on Machine Introspection.

2. Examples of Application of the System

A series of systems have been implemented by our group in Prolog from 1991 to 2011 for question answering from various text and image description bases. Our approach to question answering is based on the information extraction from text and image bases using finite state automata. The explanatory function of these systems may be considered a manifestation of their Machine Consciousness. Examples of application of our systems to a variety of question answering tasks are presented below. The presentation follows the rising level of complexity of the example bases and concludes with the presentation of novel work on the extraction of information using anomaly detection and its application to the analysis of cubist paintings.

A finite state automaton is defined by a transition table. A transition table is a set triples of the form "S1,X,S2". Where S1 is the present state of the automaton, X is the current input symbol part of the input string and S2 its the next state. A general purpose mechanism that uses the state transition table as data is specialized by it to a particular kind of text. The generation of the explanations is implemented by associating parameterized natural language messages with some of the states of the finite state automaton. Depending on the input string of the automaton part of them constitutes the explanation of the parsing of the input string as offered to the user. In what follows the input to the automaton may a single sentence, a set of sentences or a logical description of an image. A set of application examples is given below.

2.1 Extraction from single sentences of an Ancient Greek History text

The text used is part of the description of the Marathon battle by Herodotus from where the following sentence is used as an example of an input string:

". . the first thing the commanders did and this was before they left the city
was send phidippides an athenian who was a professional courier to sparta with a message . "

The explanation generated is as follows:
THE VERB <left> IS FOUND
THE VERB <send> IS FOUND
BECAUSE THE VERB-REJECTOR <before> WAS FOUND
TO THE LEFT OF THE VERB <left>
THE ENTITY <commanders> WAS FOUND TO THE LEFT OF THE VERB <send>
THE ENTITY <phidippides> WAS FOUND TO THE RIGHT OF THE VERB <send>
THE INFORMATION EXTRACTED FROM THE SENTENCE IS:
<commanders><send><phidippidis>

This explanation is generated using a finite state automaton that parses the sentence and has the following transition table less associated messages for brevity:
tr(st,t,st). tr(st,i,st). tr(st,e,ef). tr(st,v,vf). tr(st,s,sf). tr(ef,i,ef). tr(ef,e,neg). tr(ef,v,pi).
tr(ef,s,neg). tr(vf,i,vf). tr(vf,e,pi). tr(vf,v,neg). tr(vf,s,neg). tr(sf,i,sf). tr(sf,v,vf). tr(sf,e,ef). tr(sf,s,sf). tr(pi,i,pi). tr(pi,s,pos). tr(pi,t,pos).
where tr(S1,X,S2) is a state transition triple represented as a Prolog fact and the states of the automaton may be understood as follows:
st=start state. ef=entity found. vf=verb found. sf=stopword found.
pi=intermediate correct phrase found. pos=correct sentence found.
neg=wrong sentence found.

The parsing done by the automaton consists in locating a verb related to the relation contained in the question posed and extracting the two substrings of the sentence being analyzed that appear to the left and the right of this verb and end at some stop-word or punctuation mark. More details can be found in [1]. Some of the sentences are rejected if they fail the criteria posed and constitute the set of "anomalies". In the novel development presented in this paper an explanation of the rejection is generated.

2.2 Extraction from a set of sentences of protein interaction texts from Pubmed

Given the following text fragment from PubMed to the question answering system:
1. "The p53 protein regulates the mdm2 gene"
2. "regulates both the activity of the p53 protein"
3. "The mdm2 gene enhances the tumorigenic potential of cells"
4. "The mdm2 oncogene can inhibit p53_mediated transactivation"

And given the question: "What influences p53" it generates [2] the answer:
I found that the entity <p53> is one of the tokens of the chunk <the p53 protein>
which is the chunk to the left of the verb of the sentence <1411>.
I found that the chunk to the right of the verb of the sentence <1411>
is the chunk <the mdm2 gene > and
Since its first token is not an entity, I tested the rest of the tokens.
The entity <mdm2> is one of the tokens of the chunk <the mdm2 gene >
which is the chunk to the right of the verb of the sentence <1411>.
I found that the entity <p53> is included in the sentence <1411>:<the p53 protein regulates the mdm2 gene >
I found that the entity <mdm2> is one of the tokens of the chunk <the mdm2 oncogene can>
which is the chunk to the left of the verb of the sentence <1421>.
I found that the chunk to the right of the verb of the sentence <1421>
is the chunk <p53 mediated transactivation > and
the entity <p53> is one of the tokens of the chunk <p53 mediated transactivation >
which is the chunk to the right of the verb of the sentence <1421>.
It follows that <p53> is influenced by <p53>

3. Cubism, the "Conscious Eye" Book and its "Needling"

"The Conscious Eye, Perception-Art-Informatics" was written by Polyxene Kasda in Greek (Το Συνειδητό Μάτι) published by «ΑΙΓΟΚΕΡΩΣ ΤΕΧΝΗ», 1988, Athens, Greece). This prophetic and insightful book of the eighties that explores self-awareness through the experience of modern art is now being translated in English.
Concurrently it is updated by Professor Kontos "needling" certain of its passages with short references to relevant newer publications of his group and other scientists.

The present paper is a long outgrowth that emerged from the "needling" of the following passage:

"The cubist image could be conceived as a tool of introspection, where the spectator observes the world which is inseparable from his act of observation. It announces a deep mental shift. According to their sayings the two painters did not want to state anything explicitly. They were just externalizing what was inside them."

The cubist painter attempts to enhance the depiction of a scene with pictorial elements that result from the three dimensional structure of the objects of the scene. For instance a face seen from the front may include elements seen from its profile. These distortions created by the additional elements constitute for the present approach "anomalies" from the point of view of the realistic depiction of scenes. Their introspective analysis could lead to the uncovering of rules governing the three dimensional perception of objects as these are manipulated by the viewer.

An example of anomaly computer processing and explanation generation from the partial logical representation of the painting of Pablo Picasso *Les Demoiselles d'Avignon* is given below. The painting shocked the contemporary art community because of its blatant rejection of realism. It was painted in 1907 and can be considered as one of the most important images in the history of Modern Art. This painting depicting five female nudes, or one female, seen from different angles at once, twisting and moving in a confined space, where background/foreground merge, influenced the course of art history by introducing the Cubist state-of-mind.
i.e. the state of seeing oneself seeing, thinking oneself thinking, from which one could draw an analogy with the state of mind of an Artificial Intelligence scientist.

The above mentioned turn in the history of Art was the precursor of the evolution of Analytical Cubism of Picasso and Braques who attempted to freeze the unconscious part of the process of visual perception.

4. Representation for Image Anomaly Detection

The current interest in the field of Image Anomaly Detection is caused by the possibility of applying it to a number of important fields like automated security, manufacturing monitoring, robotics etc. Image or Visual Anomaly Detection may be considered as a generalization of the string parsing problem where rejections are analysed with the aim of improving the performance of a language processing system. Therefore we propose treating the Anomaly Detection problem by generalizing our finite state automaton methods including their explanation generation aspect that may contribute to the man-machine collaboration for the optimization of the detection process.

The above generalization is based first on the generalization of the input representation. A string is a sequence of symbols or objects connected with the relation of adjacency in simple line. In contrast the objects constituting an image or scene are connected with relations further than simple adjacency such as being above or below, being inside or outside as well as properties connected with the point of viewing them qua three dimensional objects.

In the case of objects that are members of a string like words of a natural language we have used a simple representation such as a Prolog fact like w(cat, word, position) where "cat" is the grammatical category of the word, "word" is the word token and "position" is a scalar denoting the position of the word in the input string. This representation is extended for the case of objects participating in a scene for the purposes of the present paper as the form of a Prolog fact e.g. as follows:

"ob(name, part, kind, view, xposition, yposition)." Where:
"name" is the name or identifier of the object e.g. "left eye"
"part" is the larger object that the object is normally a part of e.g. "face"
"kind" is a hypernym of the object e.g. "sense organ".
"view" is the point of view the object e.g. "front" or "side".
"xposition" and "yposition" are the coordinates of the object in the XY plane.

5. A Finite State Automaton (FSA) for Anomaly Detection and Explanation

The FSA presented below detects and explains a face anomaly in the image in the image of Picasso's *Les Demoiselles d'Avignon* namely the conflicting views of the eyes with the nose.

More complex images can be checked for anomalies that are also explained demonstrating machine introspection. In order to obtain a representation of an input string to the FSA a segmentation of the image must first be performed which is outside the scope of the present paper. It is supposed that this segmentation is based on a horizontal raster scan of the image and the local recognition of the main components of a face namely eyes, nose and mouth together with the recognition of whether they are viewed from the front or from the side. XY coordinates are not needed then but an integer will specify the order that the segments are found.

It should be noted that the FSA we are presenting is a generalization of a simple FSA in two ways. First it has a vector state representation instead of the usual scalar representation which means that its state is represented by an n-tuple rather than a single symbol. Second the states of this FSA are annotated with explanation texts. In cases of qualitative reasoning and explanation of the detection of an image anomaly as is the case here the representation is simplified by omitting the position coordinates.The representation of the input as the segmented version of an anomalous face image is assumed to be in a list of Prolog facts form:

ob(eyeL, face, senseorgan, front,1). ob(eyeR, face, senseorgan, front,2).
ob(nose, face, senseorgan, side,3). ob(mouth, face, senseorgan, front,4).

Using the template "ob(name, part, kind, view,int)" where:
"name" is the name of a segment.
"part" is the larger structure that the segment is a part of.
"kind" is the hypernym of the segment.
"int" is an order specifying integer.

The transition table of the automaton of the vector state FSA for the processing of this example input consists of a list of quintuples of the form S1L, S1G, X, S2L, S2G to which explanation texts are appended. These quintuples have the form::

S1L is the present state of the local part of the state vector.
S1G is the present state of the global part of the state vector
X is the present input object.
S2L is the next state of the local part of the state vector
S2G is the next state of the global part of the state vector

The possible values of the local part of each state are {1eye, 2eyes, nose, mouth}.
The possible values of the global part of each state are {front, side}.

The explanation generated for the anomaly of the example input is:
"I found 1eye with view from the front.
I found 2eyes with view from the front.
I found nose with view from the side. THEREFORE
Anomaly found because the view of the nose is different from the view of the 2eyes"

6. Conclusions

The novel function of the system implemented is the computer generation of explanation of its reasoning of detecting an anomaly. The system method is based on a vector state finite state automaton model for the parsing of the input data.

The distortion "anomaly" in Pablo Picasso's *Les Demoiselles d'Avignon* was used as an illustrative example of application of the system. More complex images can be checked for anomalies and an explanation given as an output demonstrating machine introspection of the system's own reasoning as a special case of machine consciousness.

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Ms Polyxene Kasda has studied Chemistry-Physics in the American University of Cairo in the period 1967-1969. She obtained a B.A. in Psychology-Sociology from the Athens Deree College in 1972. She is an IAA artist UNESCO since 2002. She is the author of interdisciplinary essays and of TV and radio documentaries. She speaks and writes five languages.