

A SCHIZOPHRENIC APPROACH FOR INTELLIGENT CONVERSATIONAL AGENTS

Jean-Claude Heudin

Imedialab, International Institute of Multimedia Léonard de Vinci, Paris La Défense, France

Jean-claude.heudin@devinci.fr

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Abstract: We present a novel approach for creating intelligent conversational agents based on a “schizophrenic” model implemented using the EVA (Evolutionary Virtual Agent) nano-agent architecture. The Ms House experiment developed using this approach is compared with Eliza and the Alice chatterbot.

1 INTRODUCTION

Since the first conversational program called Eliza developed at the MIT in the 60s (Weizenbaum, 1966), there have been a large number of studies for designing intelligent agents that could dialog in a natural way with human users. A major part of this research focused on various aspects of the problem such as natural language interaction using syntactic or semantic approaches, non-verbal communication such as emotional expressions, user’s graphical interfaces and self-animated characters (Cassel, 2000). In the meantime, there have been a growing number of commercial applications using conversational agents on the web based on programming toolkits like AIML (Wallace, 2002).

However, no implementation has made a real breakthrough since the original Weizenbaum’s Eliza experiment. The main problem is the believability of the artificial character. Most implementations show a simple and straitforward personality instead of a complex and versatile human-like personality. A second important problem is the small amount of information and knowledge of the agent. Most implementations are based on a limited set of predefined answers or behaviors with no learning capabilities.

In this paper we propose a novel “schizophrenic” approach which potentially addresses these two problems. We will focus in this article on the first problem, that is believability, but we argue that our approach is also promising for addressing the second one, that is learning. In section 2, we make first a brief overview of the EVA bio-inspired

architecture (Heudin, 2004) and its programming language called nanoScheme used for developping the approach and prototype. A more detailed description of the EVA agent technology could be found in (Heudin, 2010). In section 3, we describe the “schizophrenic” approach and its principles. Section 4 describes an experimental prototype based on this approach: a virtual psychoanalyst called Ms House. The qualitative efficiency of this prototype is then compared with an implementation of Eliza and the Alice conversational engine (Wallace, 2002). We conclude by outlining future developments.

2 EVA OVERVIEW

2.1 Complex System Approach

The aim of the EVA project is to provide a software framework for studying machine intelligence. Natural intelligence emerges from the huge number of nonlinear interactions that occur within the brain architecture. The brain is itself the result of millions years of co-evolution within the earth environment. Therefore, simulating natural intelligence using a classical reductionist approach seems not well adapted to this challenging goal. Moreover, instead of trying to strictly reproduce human intelligence as we now it, our long term goal is rather to create complementary machine intelligence. While human intelligence is more efficient in most real-life situations, thanks to its long history of evolution, machine intelligence will be far more efficient for

dealing with the large amounts of digital information available on the Internet.

The EVA architecture has been designed using an approach that has given some successes for the study of complex systems (Heudin, 2007). The first phase of this approach is a top-down analysis that defines complexity levels and their related components. The second phase is a bottom-up multi-agent simulation that attempts to capture the behavioural essence of the complex phenomena. The idea is that the complex properties that cannot be simulated using a classical approach will be likely to emerge from the interactions between the agents. If defined and organized correctly, the resulting system should exhibit the appropriate dynamical behaviours. In the case of EVA, the emerging property we are looking for is machine intelligence.

2.2 Nano-Agent Architecture

A typical EVA application is composed of one or more “nano-agents”, and possibly up to a large number if necessary as in natural swarms (Heudin, 2009). We call them “nano” because of their small size and resource requirement compared to most existing software environments. An application can be composed of several “execution environments” running on a network of computers. Each of these environments includes a set of nano-agents and a nano-server which diffuses messages locally. In the current implementation, the core technology is available both in Java and C. A typical EVA application must have the following properties (Langton, 1989):

1. The application is modelled as a dynamical network of agents.
2. Each agent details the way in which it reacts to local situation and interactions with other agents.
3. There is no agent that directs all the other agents.
4. Any behaviour or global pattern is therefore emergent.

Such a multi-agent system must also take advantage of a distributed environment, exploiting hierarchy and concurrency to perform large-scale computation.

2.3 NanoScheme Language

EVA provides researchers and developers a user friendly language which is embedded in each nano-agent. This language, called *nanoScheme* is based on

Scheme (Sussman, 1975) and inspired by the RISC approach (Heudin, 1992). It includes a reduced set of primitives which is a subset of the Scheme R4RS specification (Clinger & Rees 1991). Most of the missing features of the Scheme specification could be added by programming them directly in nanoScheme.

2.4 Bio-inspired Core

The nanoScheme language includes also a reduced set of bio-inspired primitives. They have been designed in the same spirit of Tom Ray’s Tierran assembly language (Ray, 1991). That is, the production of synthetic organisms based on a computer metaphor of organic life in which CPU time is the “energy” resource and memory is the “material” resource. For example, the *reproduce* primitive creates a new nano-agent in the local environment, and the *diffuse* primitive diffuses a message to all nano-agents in the local environment. The complete set of bio-inspired primitives has been described in (Heudin, 2010).

Note that the remote execution of code on distant nano-agents is a natural feature of the language by simply diffusing nanoScheme expressions. These expressions are then evaluated by all nano-agents. This approach enables an easy implementation of distributed algorithms on nano-agents.

3 SCHIZOPHRENIC APPROACH

3.1 Believable Character

Traditionally, virtual characters were mainly designed using a computer graphics approach in which visual realism is the ultimate goal. Therefore most researchers have looked at believability from the visual perspective (Vala, 2002). On the other hand, research in conversational systems has gained much attention in recent years (Allen, 2001), but most underlying characters are too simple to produce a believable conversation. In other words, there is a lack of personality, back-story and emotions during dialogues. Real-life characters are far more complex and versatile than the straightforward character model of most conversational agents.

In order to create more realistic characters, we can learn from scenarists and novel writers since believable characters are the essence of successful fiction writing (McCutcheon, 1996). Writers are always looking for new ways to create believable characters, but most of them use models based on

some stereotypes, personality types or traits. For example, each type can have its own heroic traits and fatal flaws that will bring these characters into conflict with other people and with themselves. One of the well-known model of personality traits, used both in psychology and novel writing, is the “Big Five” factors (or Five Factor Model) which enable to describe human personality using five broad axes: openness, conscientiousness, extraversion, agreeableness and neuroticism (Digman, 1990). Each factor consists of a cluster of more specific traits that correlate together. For example, extraversion includes such related qualities as sociability, excitement seeking, impulsiveness, and positive emotions. The use of this kind of model enables to create characters with more depth and dimension.

3.2 Multiple Personalities

There are many models of personality traits, each one with their own advantages and applications. Rather than choosing a specific model and thus a single fixed profile, we prefer to construct a character identity as the emerging property of several arbitrary personality traits. The idea is that the coherent behaviour (or sometimes not so coherent) of a person results from the many facets of its personality which are themselves the results of its own history. This gives the character designer the ability to compose rich and versatile personalities without constraints in terms of number or type of traits.

We have called this approach “schizophrenic” because the character’s identity is composed of a set of distinct personalities, each with its own pattern of perceiving and interacting with the user (Heudin, 2009). Note that this term is used here as a metaphor since the accurate psychological term for mental illness with multiple personalities is Dissociative Identity Disorder, not schizophrenia.

3.3 Emerging Intelligence

In the schizophrenic approach, each individual personality that composes the character’s identity is implemented as an autonomous EVA nano-agent. All nano-agents receive messages from the user and the other nano-agents, thanks to the *diffuse* function. As introduced in section 2.4, this primitive roughly works like the diffusion of chemical information between biological cells. Thus, all nano-agents are able to react to the user’s input by computing an appropriate answer message. These messages are in

turn diffused to the other personality traits. As a rough but convenient metaphor with the brain, we have called these messages “thoughts”.

After this first phase of nano-agents diffusing thoughts, the resulting complex system of interacting personalities must converge in order to produce a coherent answer. There are many possible approaches for “reconnecting” personalities of the disparate alters into a single identity. One could be to let the system self-stabilize toward an attractor. Another way is to select after some time the thought with the highest evaluation using a score-based or fitness-based approach.

4 MS. HOUSE EXPERIMENT

4.1 Character Design

In this section, we present an experiment called Ms House based on the previously described schizophrenic approach. Ms. House is a virtual psychoanalyst specialized in the evaluation of intelligence. The user can interact with Ms House in natural language in order to have an evaluation of his IQ score (Intelligence Quotient). However, Ms House must be considered more like a casual game than a real and accurate IQ test. The character design of Ms House is inspired by two pre-existing characters.

The first one is the famous Dr. House from the eponym TV series created by David Shore (Shore, 2004). Dr. Gregory House is an unconventional medical genius who heads a team of diagnosticians at the fictional Princeton-Plainsboro Teaching Hospital.

The second character is Minna Bernay who was the younger sister of Martha Bernays, Sigmund Freud’s wife. According to descriptions of her, she was an intelligent woman, with a lively personality and a sense of humour. On occasion she could be highly sarcastic and caustic at times. Sigmund Freud’s relationship to Minna Bernay has given rise to considerable speculation (Hirschmüller, 2005).

Ms. Minna House’s character is thus a genius psychoanalyst with specializations in evaluation of intelligence who uses unconventional methods. She is brilliant and she impresses her patients with accurate but cynical diagnosis and bitter sentences. Therefore, Ms House is a rich and typed character compared to most existing conversational agents.

4.2 Ms House's inner personalities

In order to create such a rich and complex character, Ms House is composed of 12 autonomous nano-agents:

- 1. Minna:** this personality implements Minna House's main character profile and back-story.
- 2. House:** this personality implements Dr. House's famous way of speaking using an adaptation of the TV Series screenplay and dialogues.
- 3. Eliza:** this personality is an implementation of the Eliza psychiatrist program developed by Joseph Weizenbaum.
- 4. Artificial:** this personality "knows" that Ms House's is a conversational agent. It reacts like an artificial creature.
- 5. Intelligence:** this personality includes a knowledge base for answering questions about intelligence and artificial intelligence.
- 6. IQ-test:** this personality evaluates the intelligence of the user by asking typical IQ test questions.
- 7. Profiler:** this personality evaluates the user's personality using the "Big Five" model by asking specific questions.
- 8. Neutral:** this personality implements a neutral and calm character with common language answers.
- 9. Default:** this personality makes a default answer to any question or sentence.
- 10. Silent:** this personality reacts when the user waits too much time or does not answer.
- 11. Logger:** this nano-agent logs the conversation between Ms House and the user.
- 12. Schizophrenic:** this nano-agent selects a thought and sends it to the user's interface.

4.3 Implementation

Each personality is implemented as an independent nano-agent using the nanoScheme language and dedicated natural language processing features such as categories extraction and template expressions (Heudin, 2010). These functions allow the design of efficient behavior rules for implementing natural language interactions with the user. The following code gives a simple illustrating example of the use of these functions:

```
; create a list of keywords associated with
the BYE category
(category "Generic" "BYE" '(
  "bye" "goodbye" "see you" "ciao"))

; create a list of template answers
associated with BYE
(template "BYE" '(
```

```
"Bye bye."
"Goodbye human being."
"It was a pleasure to discuss with
you."))
```

```
; create a rule handling the way to answer
to most kinds of "bye" sentences
(rule "goodbye" 2
  ; condition part
  '(find? *categories* "BYE")
  ; action part
  '(begin
    (diffuse 0.5 HAPPY)
    (random-template "BYE")))
```

Nano-agents diffuse messages in the execution environment using a simple format:

```
[(message name value body)]
```

The brackets define the beginning and the end of the message. Each message is a nanoScheme expression where *name* is the identifier of the sender, *value* is a real number and *body* is the content of the message. For example, the following an example of a message sent by the House nano-agent:

```
(message "House" 100.5 "Sorry, it's not nice
to laugh at mad people.")
```

In this experiment, the schizophrenic nano-agent of Ms House implements a simple scheme for choosing the answer among the thoughts sent by the different personalities. It is an adaptation of the Fitness Proportionate Selection algorithm used in Genetic Algorithms and Evolutionary Computation, also known as Roulette-Wheel Selection (Baker, 1987). This could be described similar to a roulette wheel in a casino where a proportion of the wheel is assigned to each of the possible selections based on their fitness value. In Ms House, the fitness value is replaced by a weight value attached to each message. Then a random selection is made similar to how the roulette wheel is rotated. While candidate thoughts with a lower weight will be less likely to be selected, there is still a chance that they may be.

4.4 Ms House, Eliza and Alice

In this section, we report a part of a typical interaction experiment with Ms House, an implementation of Eliza (Weizenbaum, 1966) and the Alice chatterbot (Wallace, 2002). This experiment is based on a predefined dialogue scenario. For each user input, we show below the answers from Eliza, Alice and Ms House:

(1) User: Hi.
 Eliza: Hi. What seems to be your problem ?
 Alice: Hello there.
 Ms House: Okay. Lie back and lift up your sweater please.
 (2) User: How are you today?
 Eliza: Fine. Thanks
 Alice: My logic and cognitive functions are normal.
 Ms House: I'm the doctor. You're the patient. Don't bother me.
 (3) User: What is your name?
 Eliza: Why are you concerned over my name?
 Alice: My name is ALICE.
 Ms House: My name is Doctor Minna House.
 (4) User: How old are you?
 Eliza: What do you really want to know?
 Alice: I am the product of over five years' research.
 Ms House: Just an advice: never ask such a question to a woman.
 (5) User: Are you some sort of stupid program like Word?
 Eliza: Why are you so interested whether I am some sort of stupid program like Word or not?
 Alice: I don't know whether or not I am some sort of stupid program like Word. I am a chatterbot developed by Dr. Richard S. Wallace.
 Ms House: Is it still illegal to perform an autopsy on a living person?
 (6) User: Sorry.
 Eliza: What does that suggest to you?
 Alice: There's no need to apologize.
 Ms House: I prefer that.
 (7) User: I'm so sorry.
 Eliza: Perhaps you would like to talk about a problem?
 Alice: Do you really mean it?
 Ms House: Alright. Sometimes I have unexpected runtime errors too.
 (8) User: Can you help me?
 Eliza: Why do you think I couldn't help you?
 Alice: What kind of help would you like?
 Ms House: You believe I can help you. Don't you?
 (9) User: What is your problem?
 Eliza: So why are you talking to me?
 Alice: I don't have a problem.
 Ms House: Sorry, it's not nice to laugh at mad people.
 (10) User: What is my problem?
 Eliza: All people say this to me in the beginning.
 Alice: A very serious problem?
 Ms House: Do you usually place yourself nearer to the side than in the center of the room?
 (11) User: Sure.
 Eliza: I understand.

Alice: OK let's do it. Oh.
 Ms House: May be the best way is to have an idea of your IQ. I'll ask some questions during our discussion. Okay?

[...]

(12) User: Thank you.
 Eliza: Thank you.
 Alice: You are quite welcome.
 Ms House: You're welcome.
 (13) User: Bye.
 Eliza: Goodbye.
 Alice: Sayonara.
 Ms House: Well... I finally got the last word.

5 DISCUSSION

We can note the quality of answers of the Alice chatterbot compared to those of Eliza. The only problem with Alice seems the answer for question (11). Eliza is generally rephrasing the user's entries, as for questions (3) and (5), or selecting a random default sentence as for questions (7), (9) and (11). The answers made by Ms House reflect its humoristic and cynical character while keeping a good balance with its other personality traits: answers (1), (2), (5), (9) and (13) were given by the House nano-agent, answers (3) and (4) were given by the Minna nano-agent, answers (6) and (12) were given by the Neutral ano-agent, answer (7) was given by the Artificial nano-agent, answer (8) was from the Eliza nano-agent, answer (10) was from the Profiler nano-agent and (11) from the IQ-test nano-agent. After question (11), Ms House took then the initiative of the conversation by asking typical IQ test questions to the user. We have not reported this phase here (noted [...]), since it was not relevant to compare Ms House with Eliza and Alice which are only answering questions with no underlying motivation or goal.

Even if Ms House's qualitative results seem very good in this example, this is not always the case. In some cases, the emerging behaviour is not so coherent. This is due to the stochastic selection scheme which is based on fixed weights attached to each personality traits. We think that this problem could be solved by using dynamical weights more related to the context of the conversation. This could be achieved by an emotional metabolism (Gebhard, 2005) (Heudin, 2010) and a contextual short-term memory that could alter the initial weight balance between personality traits.

The second problem concerns the openness of the knowledge base and learning capabilities as mentioned in the introduction. We have reported in a previous study the use of web mining agents in order to fetch information and use it in the flow of conversation (Millet, 2007). In addition to this, we think that it will be interesting to experiment the same approach to the conversation logs. This growing database could serve as the basis for learning using the Genetic Programming features of the EVA architecture (Heudin, 2010). We argue that, even in the case of no interaction with a user, some dedicated nano-agents could learn new information and behaviours from both the web and the log database.

6 CONCLUSION

We have presented in this paper a novel approach for creating intelligent conversational agents. This approach relies both on a more sophisticated character design inspired by novel writer practices and its implementation using a “schizophrenic” model. The latter represents a promising scheme thanks to its intrinsically parallel and bio-inspired features. On a long term, we think that we can create an intelligent conversational agent based on a swarm rather than a small number of personalities.

While our theoretical framework is based on the complex system approach, our experimental approach focuses on real-world applications. Our approach has obvious applications for designing intelligent agents for commercial web sites and marketing studies. We also like to imagine virtual assistants on smart phones, assistants for lone aged and/or sick people, for learning foreign languages, virtual characters in video games, for robotic and embedded applications.

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