University of São Paulo

Polytechnic School of Engineering

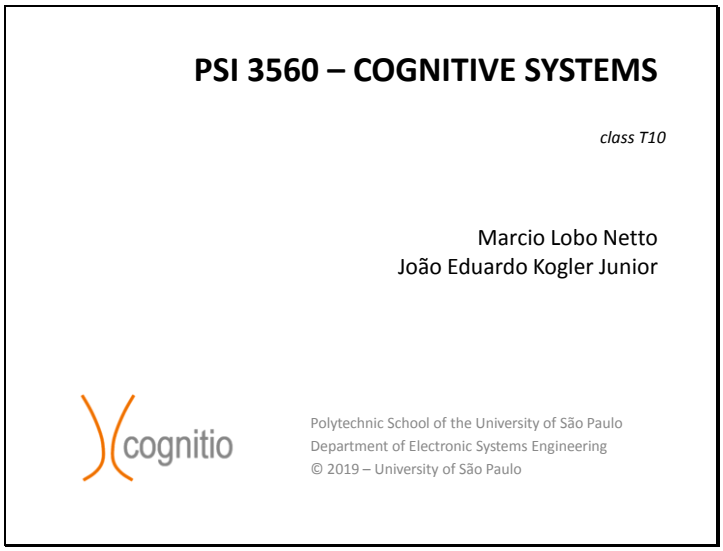
Department of Electronic Systems

Handouts of slides of class T10 – Adaptive systems

Date: May 31, 2020 Author: João E. Kogler Jr.

During the COVID-19 pandemic, with remote classrooms, I am providing this text to compensate the lack of face-to-face contact that we are experiencing. I expect that you read this material and prepare for the remote discussion session, on May 5, via teleconference. Enjoy it and keep yourself safe and healthy.

Slide 2



The exercise corresponding to this class T10 is due to June 9 will be only the following below.

You are not asked to present anything else for T10. Just this exercise. So, do it carefully.

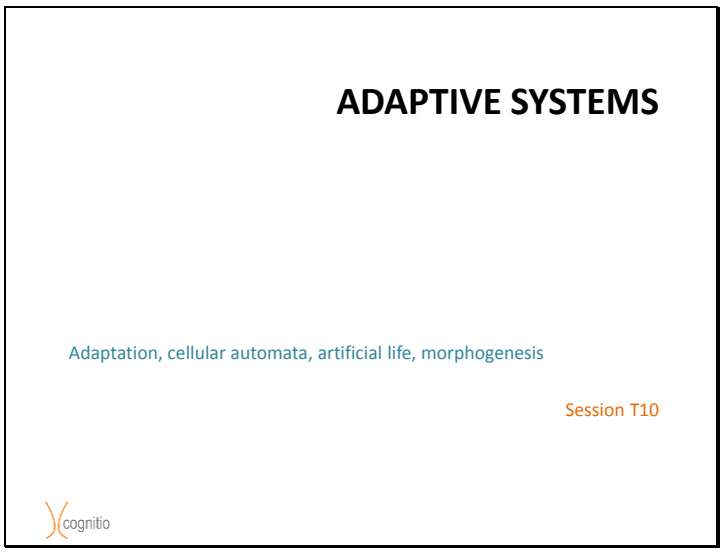
Exercise:

Write in a blank page the following and send it in pdf format to my email (kogler@lsi.usp.br) and submit it in the homework entry of Moodle for PSI3560:

- Name, date.
- I want to build a: *Title of your project* .

You will now review all steps that you previously have done to your project, observing what is going to be discussed in this class T10. Study the following pages of class T10 and notice that it is an example of how to proceed. It presents a project previously done by one of my past students for his master's program. You can base on this review to get inspiration for the revision of your own project.

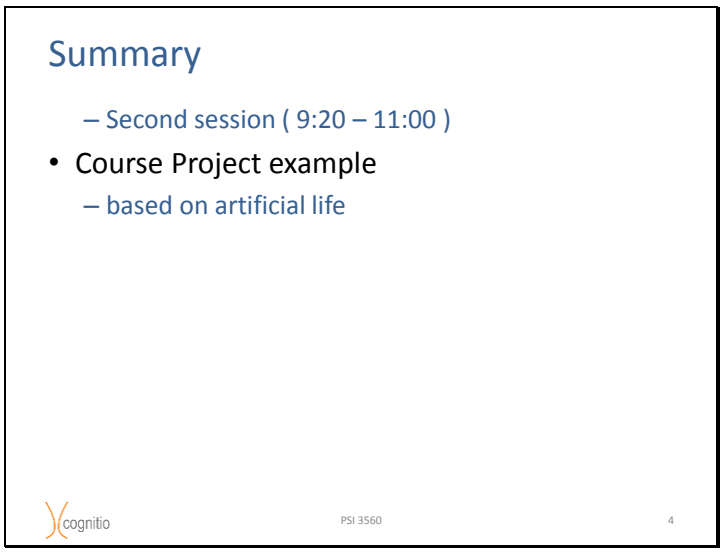
Slide 3



Let us do now a quick review of our T classes concerning on how to design a cognitive system:

- On class T1 we studied the design steps for an application and investigated how the requirement of being a cognitive one would affect these steps. Then we provided a working definition of cognitive process and cognitive system, pointing that the latter could be a cognitive tool or a cognitive agent, which possesses cognition.
- On class T3 we detailed these ideas and proceeded to the modelling of a cognitive system, extending Marr's model to cognitive systems. Then, we showed that there are currently three classes of models for cognitive systems: logical-deductive systems used by classical A.I., statistical-inductive systems used by machine-learning A.I., and dynamical-adaptive systems used by computational intelligence approaches like evolutionary computation and artificial life.
- On classes T5 to T9, all these classes were studied, in more detail.

Slide 4

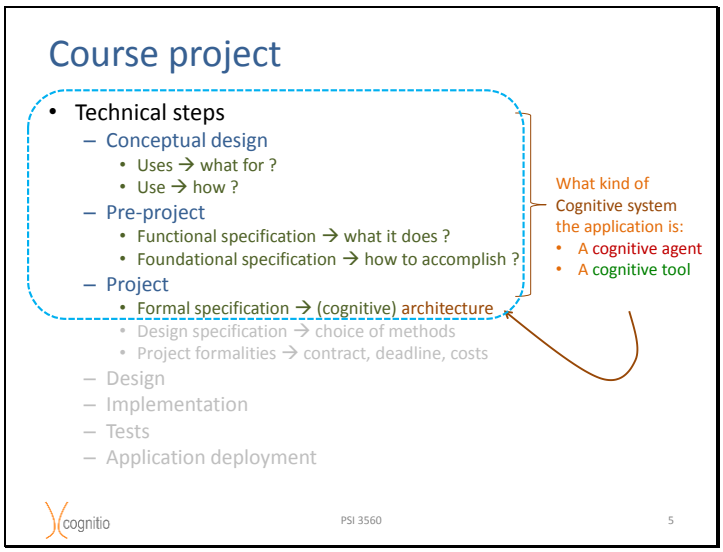


In this class, we will present a project of a former student whose master's program and project I advised on 2000-2004, with the collaboration of Marcio Lobo, here at Poli-USP, and we will review it using methods and concepts studied on our previous classes, as an example of how you could proceed and apply to a revision of your own project for this discipline.

The theme of the alluded project was an application of artificial life to build characters for computer graphics animation for movies. It was developed by Fabio Roberto de Miranda, former student on electrical engineering, and of the master's program both at Poli-USP. The main reference for this work is:

MIRANDA, F. R.; KOGLER JR, J. E.; HERNANDEZ, E. M.; NETTO, M. L. - **An artificial life approach for the animation of cognitive characters**. Computers Graphics, Elsevier, Amsterdam, v. 25, n.6, p. 955-964, 2001. doi: 10.1016/S0097-8493(01)00151-0 (link to publication)

Slide 5



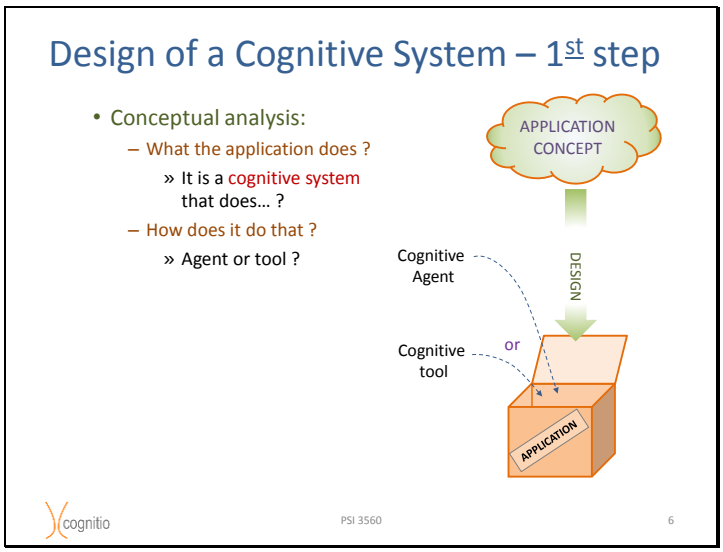
As we have being mentioning since our first T class, you have to present to this discipline a project of a cognitive system, which must comprehend the steps illustrated in the slide above:

- Conceptual design
    - First step - Informal conception of the application
    - Second step – formal statement of the application concept
- Third step - Pre-project
- Fourth step - Formal specification of its cognitive architecture

You will not be asked to perform the further steps, which consist in the design specification, project full proposal, technical design and implementation, and application test and deployment.

In the next pages, we will perform these four steps for the example application.

Slide 6



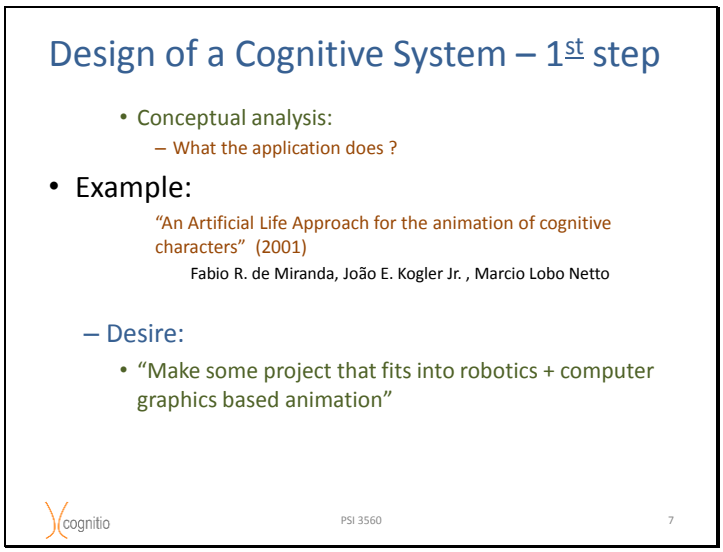
The first step of application design is the conceptual design.

This step comprehend on conceiving and describing the application. In this step, we must answer the questions indicated in the slide above.

Since your project is a cognitive application, you must say during the description of your application why it is required to be cognitive. Your answer must go in the direction of justifying that your application needs cognitive processes in its functioning.

Then you must characterize your cognitive system as a tool or as an agent.

Slide 7



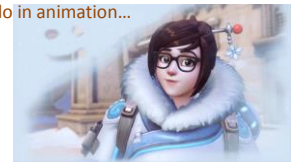
So, for the example, we will start in the same way that you should proceed, with the conception of the application.

The application of the example was born with the desire expressed by Fabio Miranda, then a recently graduated student on electrical engineering, of following a path in his master's program research that lead to the development of an application that comprehend both robotics and computer graphics based animation.

Slide 8

Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?
- Example:
  - Desire:
    - "Make some project that fits into robotics + computer graphics based animation"
      - Let's check what people do in animation...



>>>>>> Play Mei animation file

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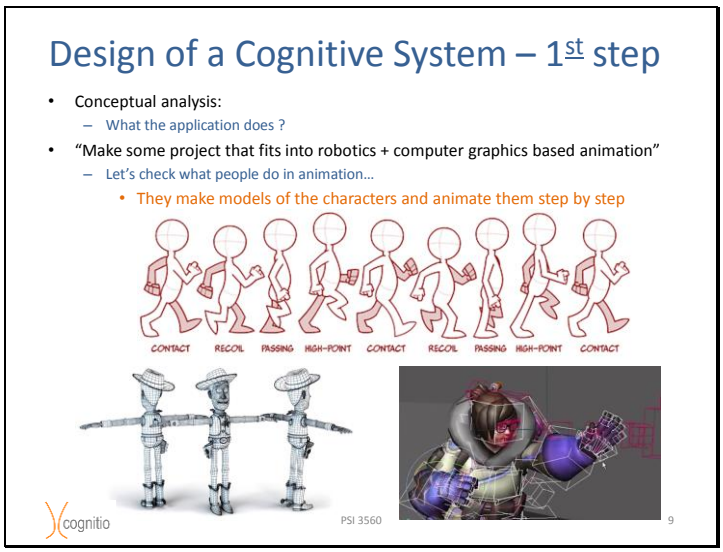
As his advisor, then I started discussing with him how we could accomplish such a project. The first idea that came up to us was to build animated characters capable of some autonomous behavior, i.e., cognitive characters. This would be quite a challenge for that time, when the workflow of animation character design followed the classical animation approach, illustrated by the video below.

Mei animation – watch video on moodle of PSI 3560 – Cognitive Systems.

Slide 9



So, in order to tell what the application does, we should translate the desire of making some application that mixes robotics and computer graphics, into an application that targets to character design and animation with computer graphics. Besides, we should treat them as virtual robots capable of some autonomous behavior adapted to a particular script of some animated story, for using in a movie.

Therefore, we should study the requirements and methods employed on this kind of application in order to conceive ours. The same that you have to do for your application project.

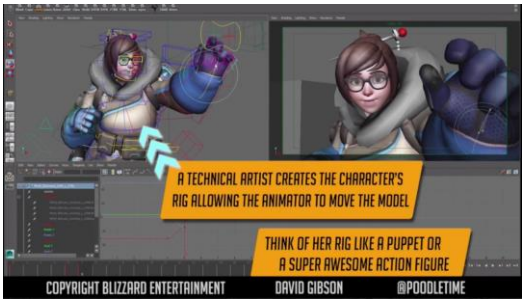
In our case, this meant that we should look for what computer graphics animators did at that time, when they animated the characters.

The first conclusion was that the characters should be presented at each movie frame, displaying a configuration that correspond to a single step of the motion that the character would perform in the frame sequence of that movie.

Slide 10

Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?
- "Make some project that fits into robotics + computer graphics based animation"
  - Let's check what people do in animation…



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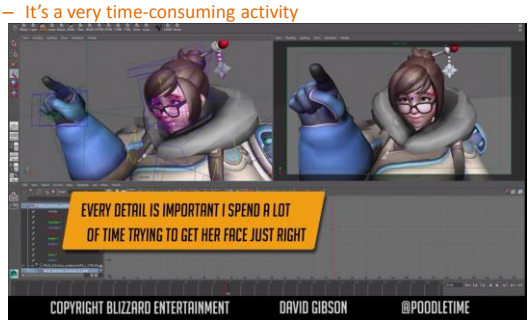
Slide 11

Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?
- "Make some project that fits into robotics + computer graphics based animation"
  - It's a very time-consuming activity



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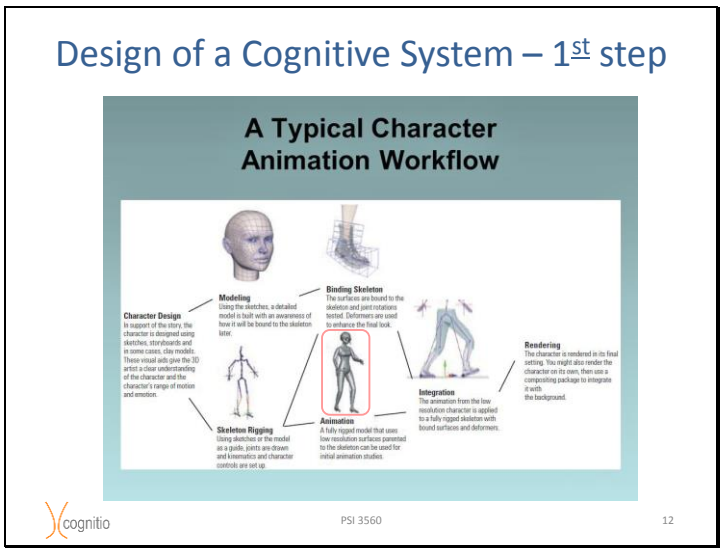
Then we found that for sophisticated characters this could be a very complex, difficult and time-consuming activity. This was in general demanding the work of many animators working in a big team in order to produce a movie with many sophisticated characters performing collectively actions in complex situations. That was the scenario on year 2000.

Slide 12

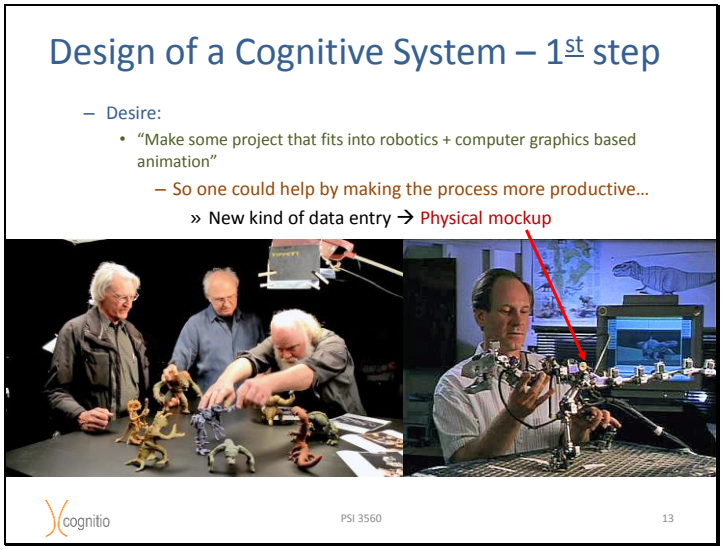


The slide above illustrates the animation workflow so employed, at that time, for the design and animation of a typical character. The step targeted by our application was that one indicated in the red contour, namely the animation step. In the previous steps, the character was geometrically created, resulting in a table describing all its components as parametrized geometric parts. Then, the animation process would consist on changing the parameters related with the movements that the character should perform, following prescriptions stated in an action script for the movie, describing the actions on each scene take. The result of the animation process would be the character in motion, interacting with the scenario and other characters. All motions and aspect changes would be described by a long list of geometric parameter changes for every character part, as shown in the video of Mei animation.

Thus, it became clear for us that we could approach animation independently of the way that the character was designed, and how the animation results were going to be used. If we provide a general method for working, it could be used for any kind of character. The animation step receives as input a character already designed, ready for animations, and produces as output the character configurations at each frame.

So, the target of our application was completely defined in a very objective way. You must do the same for your application.

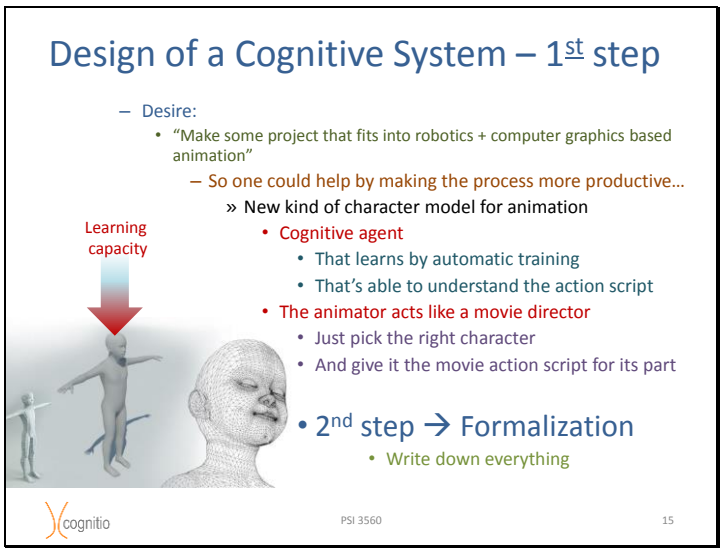
Slide 13



Slide 14

Some new methods for the automation of the animation process were beginning to appear at that time, and all of them automating the traditional approach of using human effort for controlling the parameters of the character as some kind of puppet. Therefore, we were pointing to something new, which consisted in treating the characters as virtual robots with some kind of autonomous behavior adaptable to follow the movie's action script specifications.

Slide 15



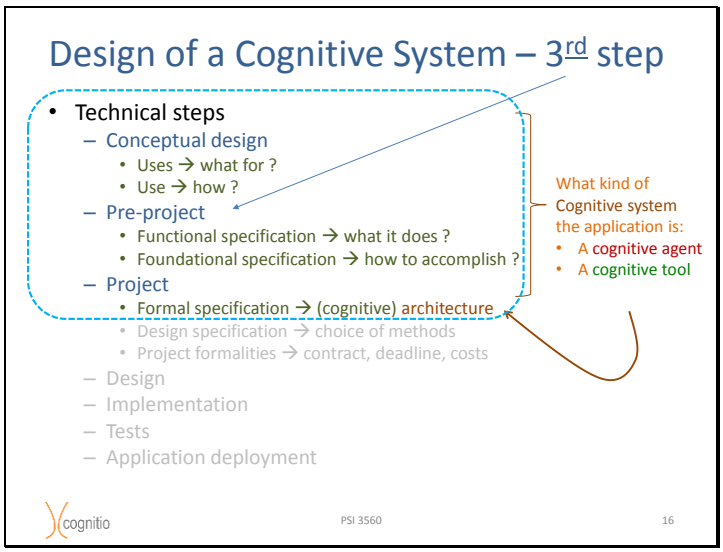
We were proposing a new method of animation, which used these autonomous robotic virtual characters, thus improving the productiveness of the animation step.

This new kind of character would be a cognitive agent, capable of learning, so it could be trained to understand the action script situation and prescriptions, for which it should be applicable. This idea opened a new perspective for the movies industry, which was that of cognitive character production factories. These factories would be large computerized facilities, in which hundreds of characters for classes of animations would be created and trained, via some learning method, to understand and perform classes of behaviors, fitted for some classes of action scripts.

Then, the application concept was finally stablished objectively. The next step should be to present it more specifically, so it could be described formally, without losing any essential detail.

This you must do for your project too. So you have to study the application domain of your idea, stated as some general desire, and made it more clear, in order to proceed to the next step.

Slide 16



Up to this point, we have taken the first step, which is the informal conception of the application. Then, now we are able to take the second step, which is, to answer explicit and formally the questions:

- Question 1: Which uses are intended for the application?
- Question 2: How the application is going to be used?

Additionally, since it is a cognitive application, there is an extra question:

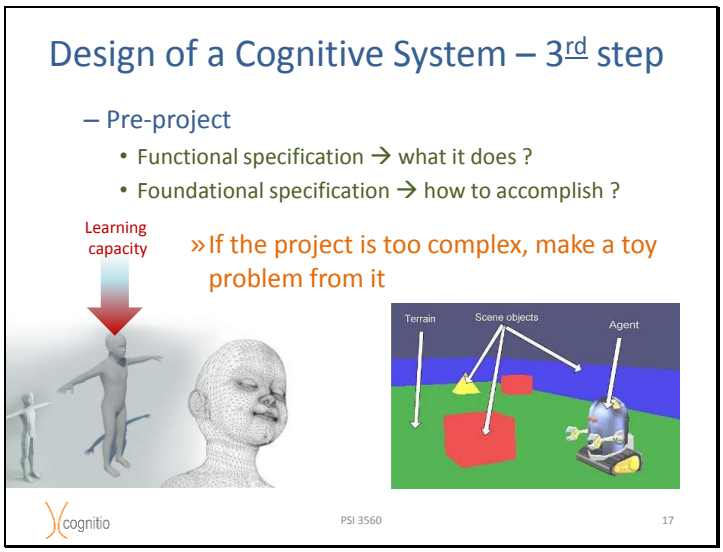
- Question 3: Why is the application a cognitive one?

You have to answer these questions for your application. In our case, the answers are:

- Answer 1: The application is targeted to the improvement of the efficiency in the process of animation of CG characters that perform action scripts in movies,
- Answer 2: By embedding a cognitive agent in the character such that it can understand and learn the action script of its part in the movie.
- Answer 3: Because the character must be capable of understanding and learning the action script.

Now, we can go to the third step of the design process.

Slide 17



In the third step, one has to provide answers concerning to specification issues, namely:

- Functional → what precisely the application has to do to accomplish its functionality?
- Foundational → how these procedures provide the required functionality?

These are crucial questions, and their answers are necessary for writing the project's proposal.

Furthermore, they will enable the technical design of the application.

In our case, the application refers to a research project of a complex entity, which is the cognitive agent, embedded in the CG character. It is complex, firstly because it is not possible to define beforehand the classes or different kinds of characters, which are constituted by arbitrary variety of types. Secondly, because there is a too many situations involving the characters in action scripts, and the combination of possibilities is inexhaustible. Therefore, in such case it is not possible to propose a general character that could be adaptable to fit the needs of every possible situation. Then, the solution is to propose a methodology for designing these characters instead providing the classes of characters themselves. Since it was not possible to prove formally the methodology, the project turned into a proof of concept. Furthermore, because the typical case could have too many parameters to control for a proof of concept, we provided the proof of concept with a toy problem.

The **toy problem** is a problem conceptually similar to the actual one, however with manageable complexity: it contains simplifications of the situations and details in such a way that none of the fundamental concepts described in the previous steps of design would be missing.

Slide 18

Design of a Cognitive System – 3rd step

- Desire:
  - Cognitive agent
    - That learns by automatic training
    - That's able to understand the action script
  - The animator acts like a movie director
    - Just pick the right character
    - And give it the movie action script for its part

- Toy problem:
  - Cognitive agent
    - That learns by performing simple actions in a simple environment
    - That's able to adapt its behavioral basis to fit to the environment
    - The adaptations will be assimilated through an evolutionary processing
  - The animator has to wait..
    - This is just a proof of concept

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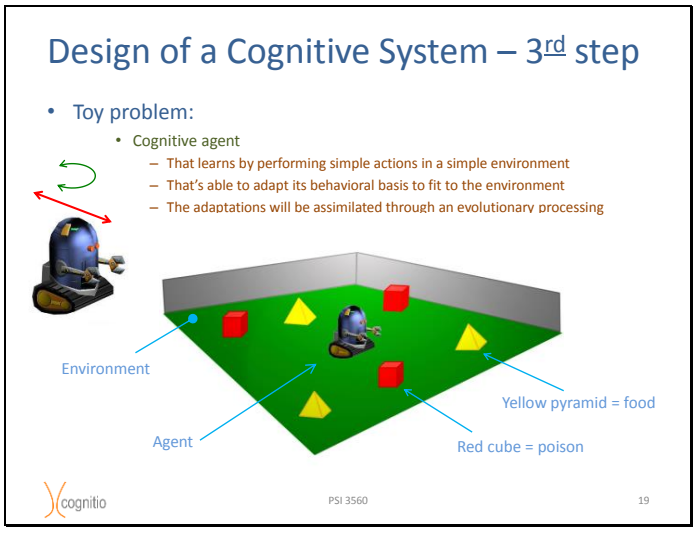
The statement of the toy problem resulted from the identification of the essential aspects of the application in the conceptual steps of design. A good strategy here is to list all these aspects and look for a simplification of their requirements.

In our case, the cognitive agent would be simplified in order to display identifiable signs that it is understanding and learning the action script, in very specific and clear situations. Nevertheless, the simplifications must be prototypical in the sense that they can represent the actual situations faced by the real application, under the conceptual aspect.

Slide 19

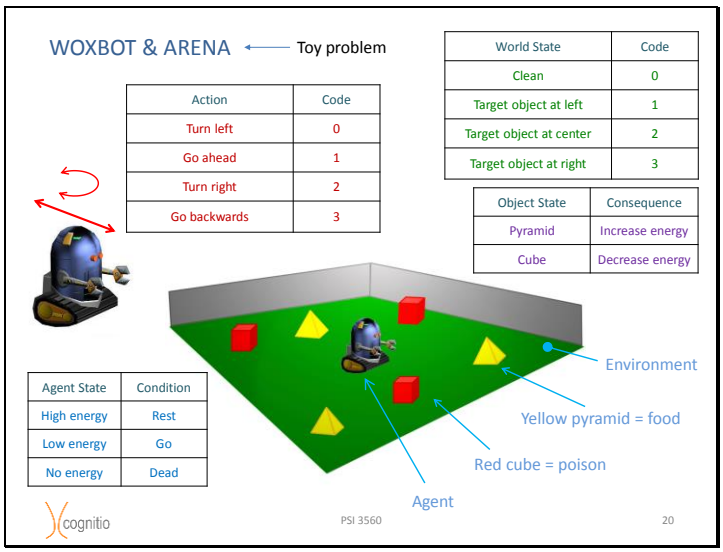


The toy problem then proposed was the following:

- The cognitive agent consists in a rigid and very simple virtual robot, capable of moving forward and backward and of rotating to right or to left.
- It performs its actions on a finite rectangular environment constituted by a green floor, surrounded by black walls, and containing two types of objects: red cubes and yellow pyramids.
- The agent is granted a finite amount of energy at the beginning of its operation, and this energy lowers with time following a fixed rule.
- The agent can recover or gain more energy by "eating" the yellow pyramids, which act as "vitamins" or "food".
- The agent loses energy when interacting with the red cubes, which act as "poison".
- The roles of the pyramids and cubes are not known beforehand by the agent, who has to learn these facts by interacting with objects in the environment.
- When the agent's energy reaches zero value, the simulation finishes with the agent's death.
- If the agent survives a long time, the simulation finishes by time-out.

The proof of concept was achieved by showing that it is possible to devise a learning process that leads the agent to understand the rules of the environment by interaction, resulting in a successful agent that remains alive until simulation time-out, for a large variety of configurations of the environment. This, in a very simplified scale, represents the ability of a character to learn its role in a play of a movie by following the action script and learning the movie's director orientations by reinforcement and correction.

Slide 20



The previous page presents the functional specification of the application. One can formalize it by encoding the possible actions and situations as in the slide above, and specifying their semantics.

These details and the description on the previous page complete the functional specification of the application. The next requirement at this third step of design is the foundational specification, describing how the agent can accomplish this functionality. Our answer for this is the following: the agent has a state machine that enables it to react to specific configurations of the environment, looking for food every time that it energy is below a given threshold.

With this, the third step is concluded, and now the next and last step required for this course is to provide the architecture, which will be the theme of the classes T11 and T12. Nevertheless, we will discuss on part II of this class some aspects concerning architectural issues particular to this project. On classes T11 and T12 more general architectures will be presented.