Intelligent Systems

Here you will find a definition of "intelligence" and also what exactly a "system" is. You will find the properties and the internal functioning of an "intelligent system" explained in detail.

What is Intelligence

There are many definitions of intelligence. A person that learns fast or one that has a vast amount of experience, could be called "intelligent". However for our purposes the most useful definition is: the systems comparative level of performance in reaching its objectives. This implies having experiences where the system learned which actions best let it reach its objectives.
For details see: What is intelligence? (Enter for continuous reading, like a book). By the way, persons are not intelligent in all areas of knowledge, they are only intelligent in those areas where they had experiences. For details see Generality of Intelligence? (Enter for continuous reading, like a book).

What is a System

A system is part of the universe, with a limited extension in space and time. What is outside the frontier of the system, we call its environment. Stronger or more correlations exist between one part of the system and another, than between this part of the system and parts in the environment. See System (Enter for continuous reading, like a book).

What is an Intelligent System

An intelligent system learns how to act so it can reach its objectives. Here is a Definition of the intelligent system (Enter for continuous reading, like a book).

Preliminary remarks on the Theory of Intelligent Systems

Here you will see how we developed the concept of the intelligent system and that we were astonished to find out that not only persons but even an artificial intelligent system in a computer needs to forget and sleep. Have a look at Preliminary remarks on the Theory of Intelligent Systems (Enter for continuous reading, like a book).

Overview of the Intelligent System

For a diagram and the relationship of the various functions of the intelligent system see further: Overview of the Intelligent system (Enter for continuous reading, like a book).

Definition of the Intelligent System

Do not take the considerations shown under What Is Intelligence (For continuous reading, like a book – do not enter here now) as a justification for the following definition. We wrote them just to show the way by which we reached the definition. We herewith, more or less arbitrarily, create a new concept, the "Intelligent System" (IS) and think it is a useful one. We have used it in building artificial intelligent systems. It seems to explain quite well some occurrences in natural intelligent systems (IS), in societies, and is useful in understanding some philosophical questions. In no sense is it a true or false definition, just a useful one. Also we are certain that this definition can be improved. [See Definitions (For continuous reading, like a book - do not enter here now)].

Here is a useful definition of an Intelligent System:

- It is a system.
- It learns during its existence. (In other words, it senses its environment and learns, for each situation, which action permits it to reach its objectives.)
- It continually acts, mentally and externally, and by acting reaches its objectives more often than pure chance indicates (normally much oftener).
- It consumes energy and uses it for its internal processes, and in order to act.

What does this definition imply?

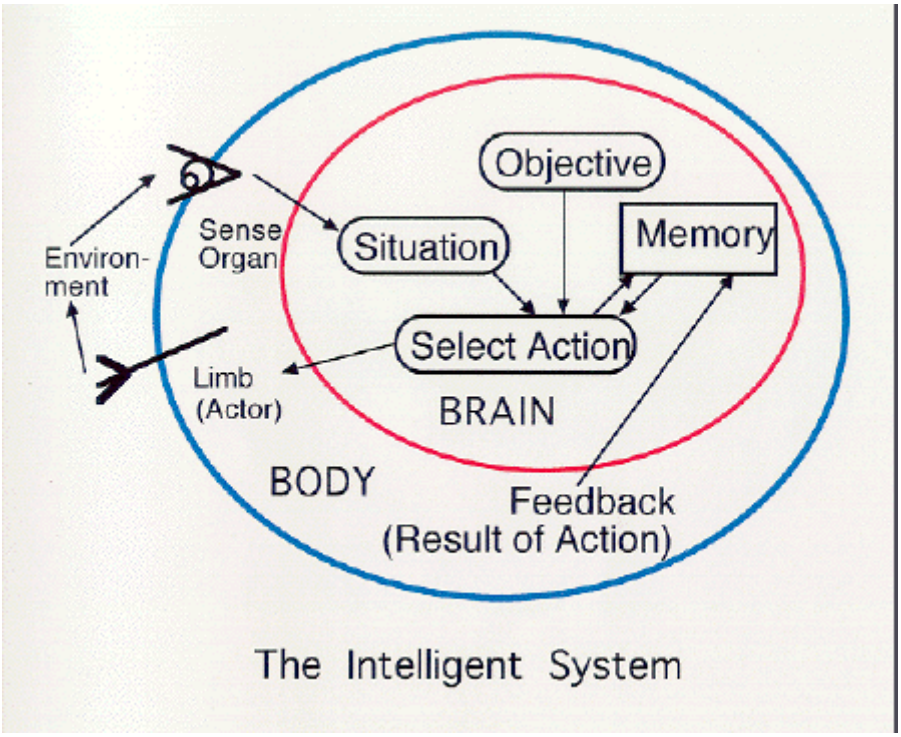
- The system has to exist.
- An environment must exist, with which the system can interact.
- It must be able to receive communications from the environment, for its elaboration of the present situation. This is an abstracted summary of the communications received by the senses. By communications, in turn, we mean an interchange of matter or energy. If this communication is for the purpose of transmitting information, it is a variation of the flow of energy or a specific structuring of matter that the system perceives.
- The IS has to have an objective, it has to be able to check if its last action was favorable, if it resulted in getting nearer to its objective, or not.
- To reach its objective it has to select its response. A simple way to select a response is to select one that was favorable in a similar previous situation.
- It must be able to learn. Since the same response sometimes is favorable and sometimes fails, it has to be able to recall in which situation the response was favorable, and in which it was not. Therefore it stores situations, responses, and results.
- Finally, it must be able to act; to accomplish the selected response.

You can go over the above noted **conditions** and check, mentally, what would happen if you cancel any one of them. We believe that you will conclude that all are necessary. If any one is absent the IS could not function.

Overview of the Intelligent System

Structure of the Functioning of an IS

The easiest way to present an overall view of structure is with a representative diagram. We have constructed one for an IS and present it below .



As you can see from this diagram, the IS is fundamentally a type of stimulus - response system. The stimulus is the sum of the communications entering through the senses. The brain extracts information from this and represents it as a situation.

Next, the IS selects a response rule, **appropriate** to the situation, and performs the response part of this rule. Here we mean by "appropriate" that performing the response permits the system to get nearer to the situation that is its objective.

The IS makes its selection of response rules from those that it finds stored in its memory. In this memory, the IS has accumulated response rules that it has generated from earlier experiences and from generalizations based on previously elaborated response rules.

"Stimulus -- Response"

Many researchers have recognized "stimulus and response" as **the** fundamental mechanism in animal activity, but nowadays, this is modified. The perceptual control theory states that often the animal acts in such a way that it changes the situation that it perceives to the situation that is its objective (see Perceptual Control Theory) (Exterior link).

But are these also the fundamental mechanisms in the human mind? At first, it does not seem possible that all (or nearly all) of the activity of the human brain could be something as simple as a type of sophisticated stimulus - response mechanism, used to reach an objective. However, we need to keep in mind that all the incredible, and varied activity that we can observe in computer systems today are based on only a few very simple capabilities, namely: to add, subtract, compare, and jump to a different place in the program. Thus, a very complex response, based on a sequence of only a few elementary activities, is perfectly possible.

Learning

By generalizing and abstracting from our experiences we can learn more general response rules. It turns out that it is this **learned** mental activity, that permits us to think and do so many things. We have learned how to walk, how to do arithmetic, how to write, how to dress and to behave, and even how to create intelligent learning systems. To a large extent we have **learned** how to think, how to make plans, how to extrapolate. This learning process starts at birth and goes on intensively for many years until the end of schooling. Even then the learning never stops.

Need for a Complete System

Researchers in the science of "Artificial Intelligence" have investigated many areas of the mind such as pattern matching, vision, and theorem proving. However, all of these are only parts of the human mind. An intelligent system could include all of these parts, but it still would not be complete, and **could not function**, unless it also had senses, a method to choose responses according to its objectives and memories, and some way of performing these responses in and on its environment.

Programming versus Learning

Since it is impossible to foresee all of the many different situations in which an artificial IS may eventually find itself, we should not attempt to program its responses. It is better if, as it goes along its way through its "life", the artificial IS learns how to act based on its own past experiences.
There are, though, a few useful exceptions to this rule. For example, an IS will greatly benefit from a few of the most basic instincts. For starters, I would include the following:

- **self-preservation (survival)** by avoiding damage to the body or mind.
- **curiosity**, to promote the opportunity for learning and thus accelerate it.
- **copying** of actions done by other intelligent systems.

Details of the Intelligent System

The main processes occurring within the intelligent systems are the following: The Intelligent System has a temporary objective, that it has derived from its main objective. It senses its environment, although we have to realize that it has only a few senses and that these can only capture, for instance, light and sound of an object, but can not capture or know the object itself.

The system then stores these sense impressions as elementary concepts. Concepts are a material way of storing information. Working on concepts it creates new ones and stores relationships to other total, part, abstract and concrete concepts. In the following we explain this in more detail.

Of course you realize that there is a difference between an object or occurrence in the environment, the concept the system uses for its internal processing and the word it uses to communicate about the concept.

To continue with the internal processes, in more intelligent systems there should now be a check of the incoming information. With all the information, expressed as concepts, the system builds up the present situation. Now it looks into its memory and finds applicable response rules. It chooses one of the best it has found and performs the corresponding action. Response rules are a field of storage that includes the present situation to which the rule is applicable and the corresponding action.

The intelligent system continually records the present situation and the action that followed as a response rule. The very first response rules are due to chance actions and to teaching. When the system is externally inactive, that is it sleeps, it reviews the response rules stored in its memory and performs some generalizations. It makes abstractions of concepts and creates the corresponding response rules, including these abstractions. Further comparisons are between the situation and action of a series or recently learned response rules as well as comparisons between situations of different response rules and between actions of different response rules. By all these activities, starting with very concrete response rules, it creates response rules that are applicable to several different but similar situations. After some while, its memory is full and it forgets the least used concepts and response rules. All this is explained at some length in Details of the Intelligent System (Enter for continuos reading, like a book).

Now you have gained a detailed knowledge of ISs. You have observed the role played by concepts, be they concrete, composite, or abstract and the role played by response rules. You have seen that most observed activity in an IS is based on response rules, chosen for the present subobjective.