An architecture of a thinking like processing system based on autonomous reaction between images


Abstract
To construct a “thinking-like” processing system, an architecture for an adaptive associative memory system is proposed. This architecture treats “images” as basic units of information and adapts to the environment by means of autonomous reactions between the images. Processing on this system are executed based on the associative memory function of input images and new images created from memorized images through image reaction. Moreover the system adapt to externality by making up prototype images of the external world.

1. Introduction
Our purpose in this paper is to describe a fundamental method for carrying out the information processing action of “thinking” on a computer. To construct such a system, we are developing an adaptive associative memory system. This system treats “images” as basic units of information and adapts to an environment of the external world by the autonomous reactions between the images and generated prototype images of the external environment.

This associative memory system is made up of nodes and links; it is called a localist spreading activation network. As the characteristics for representation of information, we assume that the “images” can be divided into smaller images that show a part or feature of the larger image, but that can still be identified as a part or a feature of the larger image. (We call this characteristic “separability.”) When an image is input to the associative memory system, feature extracting images, which are used for extracting features from the input image, transmit stimulation signals of the features of the input images to other images. As a result of spreading activation, the network outputs images from the highest activity nodes. The system learns by reinforcement learning based on the usefulness of the output images.

Images in high-activity nodes interact autonomously and generate new images and links. Various forms of images are generated automatically under constraints of links with adjacent nodes. Images are also subject to natural selection; the images in high-activity nodes survive while images in low-activity nodes gradually fade away. Based on the reactions between images and this natural selection, the associative memory system “remembers” useful prototype images, and gradually adapt to the environment. We call the memory system proposed here “Image Reactor” from the fact that the images in the system react autonomously to each other. A simple reaction model consisting of three operations (addition, subtraction, and multiplication) is proposed.

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2. Basic concepts

2.1 Basic concepts of “thinking like” processing system

This research is carried out under following concepts, for constructing a “thinking like” processing system.

(1) A “thinking like” processing system itself autonomously adapts to the environment. Such a processing system can be composed by integrating memory and information processing functions. As an integrated processing system, the memory system makes an image, using local representation, as a memory network component.

(2) The memory system adapts to the environment by generating and selecting images. Images are randomly generated based on autonomous reactions between images. However, these reactions are not generated completely randomly. The links from one image to another that control the association works as conditions of constraint.

(3) The selection mechanism of images is based on Hebbian rule, and selection of images is controlled by the level of action potential of the image has.

(4) The memory system generates prototype images through autonomous reactions between images and selection of images. These reactions are, in a sense, a primitive form of “concept generation.”

(5) The generated prototype images are strongly connected in the memory system. This strongly connected network, which is generated as a result of adaptations of the processing system, represents processing rules that are effective for the specific environment.

2.2 Image as information-representation units

In many cases, images or patterns have the following properties.

(1) Separability: Images are “separable” into smaller images that show a part or a feature of the larger image, but that can still be identified as a part or a feature of the larger image.

(2) Connectivity: Connectivity is the inverse property of separability. New images can be created by spatially combining several images into a unit.

(3) Stability (Redundancy): The meaning of what is being represented does not change much if its form changes within a certain range. That is, a minor change in an image does not change its meaning very much.

In this paper, information that satisfies the above properties is treated as an image in a broad sense, although at first glance it may not seem like an image. Moreover, in the following descriptions, the image is represented as a set of features or pseudo-features from next reasons.

(1) Set of features or pseudo-features of images obviously satisfies the three properties described above.

(2) By expressing the image as a set of features or pseudo-features, the reaction between images can be simply defined as an operation on the existence of features of each image.

This system uses local representation, which means that an image is stored in a node. This method of representation allows the content and association (access) method of the memory to easily changed independently. The advantage of enabling the memory to be changed independently is that large-capacity associative memory systems can be easily set up.
3. Configuration and image reaction

The associative memory's adaptability is realized by the autonomous reactions of the node. The autonomous reaction of an image generates new images from old images. At the same time old images with low action potentials disappear, and images that resemble other images merge into one image. By these processes of image generation, disappearance, and combination make up the natural selection of images for the whole network. Through this natural selection, the memory system itself adapts to the external environment.

Basic configuration of the image reactor are shown in Fig.1. The image reactor is composed of a preprocessing module, a feature-extraction module, a reaction module, a motor module, and a control module.

Array of pseudo-features are assumed here to be subject to three basic operations called Addition, Multiplication, and Mergence. Operations between the input image data Ia and Ib of nodes A and B generate output node C with image data Ic where image data Ia, Ib, and Ic are array of features. Addition generates composite and intermediate images, and Multiplication is a kind of abstraction from concrete images. Mergence eliminates similar images. These three operations cooperate in selecting images, so the image network constitutes a kind of concept-generation model.

4. Conclusion

We have described the architecture of a thinking like system with an adaptation function that can be used to construct a "thinking-like" processing system. Based on this architecture, we will further examine the characteristics of the image reactor, and will focus on how the image network "learns" and how the image "interact."

References
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