Chapter 6
Cognitive Memory:
Human Like Memory

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ABSTRACT

Taking inspiration from life experience, the authors have devised a new form of computer memory. Certain conjectures about human memory are keys to the central idea. This paper presents a design of a practical and useful "cognitive" memory system in which the new memory does not function like a computer memory where specific data is stored in specific numbered registers; retrieval is done by reading the contents of the specified memory register, or done by matching key words as with a document search. Incoming sensory data would be stored at the next available empty memory location and could be stored redundantly at several empty locations. The stored sensory data would neither have key words nor would it be located in known or specified memory locations. Retrieval would be initiated by a prompt signal from a current set of sensory inputs or patterns. The search would be done by a retrieval system that makes use of auto-associative artificial neural networks. In this paper, the authors present a practical application of this cognitive memory system to human facial recognition.

INTRODUCTION

Pattern recognition remains an elusive art, even after decades of work by thousands of people in the field worldwide. Some progress has been made. You can now phone an airline company, talk to

a computer, and make a flight reservation. There are other examples of practical applications of current methodology, but they all exhibit far from human-like capability. What is it about humans and animals that give them such an amazing ability to recognize objects and patterns? Why after all these years are we not able to approximate animal capability for pattern recognition by artificial

means? Is there something magical or supernatural about humans and animals? Or are they simply machines of great complexity? What is it?

We believe that humans and animals are superbly capable complex machines, not possessing supernatural powers. Believing that, we try to understand the mechanism, the action that takes place when we are seeing and hearing, and in particular, how we recognize patterns. Fundamentally, human and animal pattern recognition involves matching an unknown incoming pattern with a pattern seen before and currently stored in memory. Not everyone will accept this, but this is what we believe.

During a visit when an interesting subject is being discussed, the "mental tape recorder" is recording in memory the sights, sounds, etc. of the visit. In a half hour of discussion, perhaps 100,000 images of the visitor's face are recorded. These images are retinal views that capture the visitor's face with different translations, rotations, light levels, perspectives, etc. These images are stored permanently in memory, wherever there is an empty place. Unlike a digital computer with numbered memory registers where data storage locations are program controlled, and data is retrieved when needed by calling for it by register number, human memory has no numbered registers. Data is stored in human memory wherever there is an empty place and once stored, the memory has no idea where the data has been stored.

We contemplate a memory of enormous, almost unbelievable capacity, enough to hold many lifetimes of stored visual, auditory, tactile, olfactory, vestibular, etc. patterns of interest. Data and patterns are retrieved in response to an input pattern, whether visual, auditory, tactile, etc. or a combination. The input pattern serves as a prompt to initiate retrieval of data patterns related to the prompt, if they are stored in the memory. If data patterns are retrieved and if they contain an identification, the input pattern is thereby identified.

It is surprising that many aspects of human mental activity can be explained by such a simple idea of memory. Some of these aspects will be described below. On the engineering side, we will introduce new approaches to computer memory, to pattern recognition, and to control systems.

Pattern matching is complicated by the fact that unknown incoming prompt patterns may be different from stored patterns in perspective, translation, rotation, scale, etc. Simple pattern matching may not be adequate, but this will be addressed.

The memory capacity must be enormous, and it should be implemented with a parallel architecture so that search time would be independent of memory size. There are many ways to structure a content-addressable memory. The "cognitive memory" proposed herein is of a unique design that could be physically built to give a computer a "human-like" memory, and furthermore, it is intended to serve as a behavioral model for human and animal memory.

A simplified block diagram of a cognitive memory system is shown in Figure 1. The memory of Figure 1 is divided into segments. Each segment has a set of memory folders capable of storing visual auditory, tactile, olfactory, etc. patterns and if the system were artificial, it could store radar, sonar, and other sensory patterns. Each segment has its own autoassociative neural network.

During a visit, images of the visitor's face, voice sounds, tactile images, olfactory patterns, etc. are stored together in one of the empty folders. These patterns arrive on the memory input line of Figure 1. They come from visual, auditory, etc. sensors, having gone through the visual, auditory, etc. cortexes respectively.

The various sensory patterns, having been recorded simultaneously in the same folder, are permanently associated with each other. The result is that, when the contents of a folder are retrieved in response to a visual prompt which may be the image of a singer, in one's mind, the sound of the person singing can be "heard." If the prompt is the sound of singing, the image of the singer's face can be "seen" in one's mind. If the prompt

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