In D. Reitter & F. E. Ritter (Eds.), Proceedings of the 14th International Conference on Cognitive Modeling (ICCM 2016). University Park, PA: Penn State.

Modeling Autobiographical Memory from Photo Libraries

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Abstract

Assuming that photographs accumulated on a personal computer reflect the life history of a person, a model of that person's autobiographical memory could be constructed. Such a model would be useful to overcome memory problems caused by factors such as aging. On the basis of this idea, we constructed a photo slideshow system comprising an ACT-R model with a private photo library.

Keywords: Photographs, Autobiographical Memory, ACT-R.

Introduction

Recalling autobiographical memory engenders a state of consciousness, called mental time travel, in which relevant memories of past events are evoked (Schacter, Addis, & Buckner, 2007; Tulving, 1985). Memory recall of a personal golden age is also said to bring psychological health and well-being (Routledge, Wildschut, Sedikides, & Juhl, 2013). On the basis of these assumptions, activities such as life reviews and reminiscences are conducted to support the elderly.

Our long-term goal is to develop a model-based method of life review and reminiscences, in which a computerized user-model guides user's mental time travel. To establish this, we developed a photo slideshow system by using ACT-R as a user-modeling platform (Anderson, Boyle, & Reiser, 1985; Anderson, 2007). In this framework, a cognitive model of a user's autobiographical memory is developed by extracting user-specific knowledge from a private photo database.

In this framework, the model and user simultaneously observe a photo retrieved by the model. When a memory recalled by the model satisfactorily fits that of the user, the photo presented by the model can generate a positive feeling in the user through synchronization effects (Chartrand & Bargh, 1999). Such synchronization effects can be strengthened by modulating parameters of the model utilizing feedbacks from users. Therefore, we assume that this slideshow can be used for not only motivating a user by presenting favored photos but also diagnosing mental states through user feedback of the presented photos.

The model

This document briefly presents the construction of the model, which uses the visual, declarative, goal and production modules of ACT-R to retrieve photos from a photo library.

Photo data and Visual Module

The outputs from a consumer-based image processing engine are used as inputs to the model. Many recent photo libraries have face detection modules. They can also recognize personal names through human-in-the-loop training. We used these functions implemented in iPhoto of Mac OSX. We also used ReKognition API (https://rekognition.com) to analyze the scenes in photos. ReKognition API is an image recognition engine that has already learned connections between visual features and scene tags such as "cats," "cars," and "people." The faces and scenes extracted from the photos are displayed on an AGI (ACT-R Graphical Interface) screen as "texts" to make the ACT-R model observe the photo.

Declarative Module

Figure 1a presents examples of declarative chunks. In the examples, *** represents arbitral strings for labeling each chunk, and $< GUID >$ corresponds to photo ID. The top three chunks represent the meaning of the texts displayed on AGI. The bottom three chunks represent attributes of photos. We coded four types of attributes corresponding to "What," "Who," "Where," and "When," following a psychological study of autobiographical memory (Wagenaar, 1986).

The "Who" attribute Using iPhoto face recognition, the two types of chunks signified in *I* and *IV* in Figure 1a were constructed. The chunk *I* associates the text "face753" with a face whose ID is 753. The chunk *IV* states that the photo with ID $< GUID >$ includes face753. The first type of chunk is used to recognize a face from a text on the AGI display. The second type is used to retrieve a photo that includes a recognized face.

The "What" attribute The two types of chunks were constructed from outputs of ReKognition API. As in the case of faces, the chunk *II* in the Figure 1b is used to recognize a scene from the AGI screen. The chunk *V* is used to retrieve a photo including s-broom.

The "Where" attribute This attribute signifies the geographical locations in which the photo was taken. Although recent digital photos have geotag information embedded in their Exif metadata, symbolization of continuous values of latitude and longitude is needed to construct the where attribute for ACT-R. We used the x-means clustering algorithm

to symbolize the location data. Once clusters are made, each location is encoded into the chunk *VI*. The geo30 in the chunk represents a cluster ID. Using this chunk, the model retrieve a photo that shares a geo cluster with the current photo.

The "When" attribute Like the where attribute, the when attribute can be constructed by clustering date-time information embedded in the Exif metadata (the chunk *VII*). In the case of the when attribute, we used k-means with the number of clusters determined by x-means for the where attribute to uniform resolutions of the two attributes.

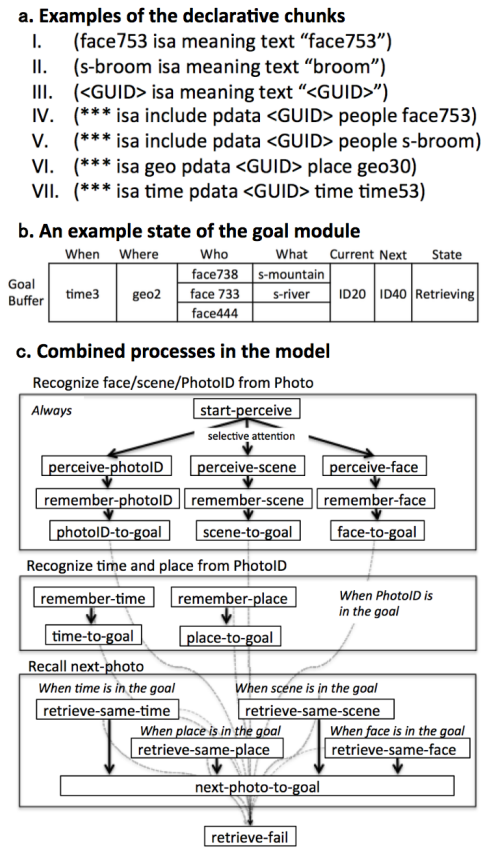

Figure 1: The ACT-R model of autobiographical memory constructed from a photo Library

Goal Module

The ACT-R's goal module is used to hold information associated with the four attributes recognized from the photos. It also holds the current photo ID (the *current-photo* slot), next photo ID (the *next-photo* slot), and the state of the model (the *state* slot). Figure 1b shows an example state of the goal module. The slots for the who and what attributes are defined as pushdown stacks with a size of three.

Production Module

Using the visual input and the declarative memories explained above, the model observes information on the current photo, and retrieves the next photo from a declarative memory. This process corresponds to a free recall of episode memory.

Figure 1c shows the production rules of the model as 19 sets of boxed texts. The rules make up several independent *processes* where arrows connect them. When any process terminates, the state slot of the goal module is changed to *start-process*, and the next process begins. The process has different triggering conditions described as *"always"* or *"when..."* on the figure. When the several processes simultaneously have conditions that correspond to the current state, the current model randomly starts one of the processes. In the future implementation, feedbacks from users would enable the modulation of the probability of a process being selected.

The box at the top of the figure includes processes recognizing visual objects on the AGI screen. The start-perceive rule starts this process by randomly choosing one set of texts from the screen. The ensuing three rules, *remember-photo-ID*, *remember-scene*, and *remember-face*, retrieve chunks that connect visual texts to corresponding chunks (the chunks *I* to *III*). If the retrieval succeeds, the model places the chunk on the corresponding slots of the goal module (*photoID-to-goal, scene-to-goal, face-to-goal*). The middle box in the figure corresponds to the recognition process for the where and when attributes. This information does not directly on the screen. We assume that these attributes are recognized from an intrinsic visual feature of the photo, namely the photo ID. When the current photo ID is in the goal buffer, the *remember-time* and *remember-place* rules retrieve chunks that describe date-time (the chunk *VII*) and location (the chunk VI), respectively. The box at the bottom indicates the retrieval process for the next photo. Each process is triggered by the state of the corresponding slots of the goal module. The tag information in the goal module is used as a query to retrieve chunks including photo ID (the chunks *IV* to *VII*). Once these chunks are retrieved, the retrieved photo ID is stored in the next-photo slot of the goal module.

The model repeats these processes in a *trial*, with the same photo is presented on the screen. During the trial, every time the processes in the boxes at the top and in the middle are triggered, the slots in the goal module are filled. The next-photo slot of the goal module also changes every time the processes in the bottom box are triggered, but it decides which photo to present in the next trial at the end of each trial. Thus, the longer the duration of the trial or the faster the cycle of the model, the richer the information for the retrieval of photos becomes.

Summary

This document described how an ACT-R model of autobiographical memory could be developed from a photo library. In the future paper, we will describe the subsymbolic computation of the model. We are currently developing an interface modulating model parameters by user's behavioral and physiological reactions.

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