CONSTRUCTING MUTUALLY- DERIVED SITUATIONAL AWARENESS

INTRODUCTION

As computer storage increases and sensors proliferate, we increasingly encounter environments in which a large quantity of data is available, from satellite imagery to the GPS-tagged images of Flickr. This abundance of information, however, is not enough to derive the situational awareness needed to direct intelligent decisions in an environment. In pursuit of such situational awareness, we have developed a BCI system that fuses a human brain’s local comprehension with a large database’s expansive scope. The system first classifies EEG signals from users as they search a small sample of a virtual environment for objects of interest. It then employs a computer vision (CV) system to extraplate the EEG-based predictions to all objects in the environment, and it determines an expeditious route that will allow the user to investigate the predicted targets. This arrangement results in more efficient searches of a large environment for objects of interest.

SYSTEM OVERVIEW

Graph Construction

A CV system called Transductive Annotation by Graph (TAG) is used to construct an affinity graph containing all the images in the environment, using the pairwise similarity between images in gist-feature space to determine connection strength [1]. (Thick gray lines indicate strong connections.)

EEG Classification

An EEG classifier is applied to the EEG data evoked by each image that the subject views. The images evoking the highest “interest scores” are labeled as EEG predicted targets (EEG-pt). (If the subject traverses the dotted black line looking for saliboats, the images outlined in pink would ideally be the EEG-pt set.)

CV Extrapolation

The EEG-pt labels are propagated through the TAG to produce a “TAG score” for every image in the environment, such that images with the strongest connections to the EEG-pt set would be scored most highly. The images with the highest TAG scores are labeled as TAG predicted targets (TAG-pt). (The images outlined in green would be the TAG-pt set.)

Route Planning

To help a user to investigate the TAG-pt images efficiently, we use a traveling salesman algorithm to plot the shortest course that visits all the TAG predicted targets in the virtual environment. (The black dotted line indicates the new route.)

METHODS

Immersive Environment, Free Viewing

Subjects were navigated through a virtual 3-dimensional environment as if following a car down a windsing street with alleys on either side [2]. Some randomly selected alleys contained “billboards” displaying images from a 4-category subset of the Caltech-101 database, such that images gradually became visible as the subjects passed them. Subjects were asked to count images of one category (targets) and ignore the others (distractors). Subjects were also asked to press a button when the car in front of them put on its brakes, a secondary task designed to keep the subjects engaged and default their gaze to the center of the screen. Each of 3 subjects viewed ~10% of a 1600-object environment in which ~25% of the images were targets.

RESULTS

For two of the subjects (S1 and S2), our classifier produced EEG-pt sets with greater precision than chance (33% and 63%). For these subjects, the TAG-pt set had an even greater precision, and our system’s route would successfully speed up search, allowing the user to view more than 90% of the true targets by traveling less than 50% of the distance it would take to see all of the images. The third subject (S3), however, had an EEG-pt set with precision equal to chance (25%). The TAG-pt set for this subject was mostly distractors, and the system therefore produced a route that visits less than 10% of the true targets.

CONCLUSION

Our results indicate that the proposed system can expedite searches for objects of interest in a large mapped environment. However, for one subject, the EEG was classified poorly, the system converged on an incorrect set, and search was significantly slowed. Future work will endeavor to prevent such catastrophic failures by improving the performance of our EEG classifier. The resulting system could be adapted to fuse information across sensing modalities, using whatever object data is available to leverage complex human understanding into far-reaching situational awareness and create efficient searches.

REFERENCES


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