TotemFinder: A Visual Analytics Approach for Image-based Key Players Identification

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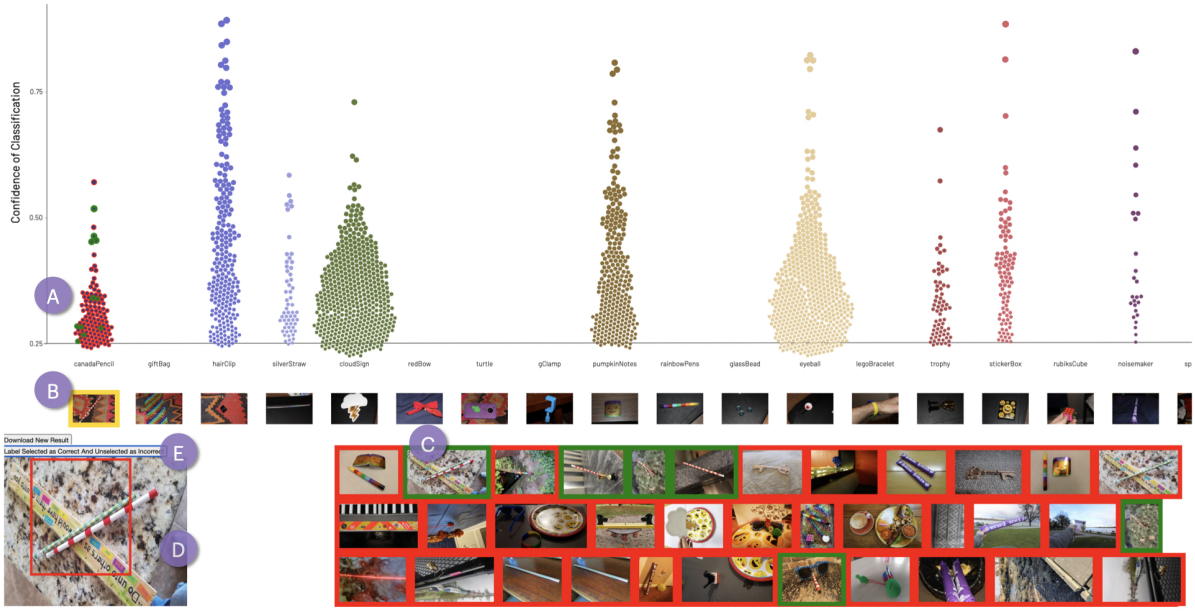

Fig. 1. TotemFinder supports identification of key players in a social network based on shared objects in their image collections. Here, in Interface #1, objects in the image collections have been predicted via an image classifier. (A) Beeswarm charts bin predictions according to their class; each prediction is a circle, and vertical position shows the prediction's confidence. (B) The user can select a class by clicking its reference image to and review its individual predictions. (C) Individual predictions can be reviewed, and (D) correct predictions can be selected (green borders). (E) A batch update labels all selected images as "correct" predictions and unselected images as "incorrect" predictions (red borders). Subsequent interfaces (Figs. 2 and 3) can be used to update incorrect predictions and identify key players in the social network based on shared objects.

Abstract—We present TotemFinder, an interactive visualization system for the analysis of the VAST 2020 Mini-Challenge 2 (MC2) dataset. The system consists of three interfaces: Interface #1 allows users to quickly verify the correctness of object predictions of a machine learning-based image classifier. Interface #2 uses a customized image explorer to support relabeling incorrect object predictions identified in Interface #1. Interface #3 employs several coordinated visualizations (such as a filterable ontology graph) to investigate the distilled object data to identify person groups based on shared objects in their image collections.

Index Terms—Visual Analytics, Image Classification, Social Networks

1 Introduction

The second Mini Challenge of VAST Challenge 2020 [1] introduces a fictional scenario where a cyber event happens and its resolution depends upon a group of eight people, who need to be identified out of a pool of forty candidates. Available data are social media posts (pictures and captions) for each candidate. The eight key players symbolize their affiliation with a totemic object that appears in some of their social media posts. The totem must therefore be identified, however this is a non-trivial task a large number of images exist among the forty candidates. To help investigate the social media posts and identify the totem, we design a novel visualization tool called TotemFinder. After the application of a trained image-based classifier to extract the objects in each social media image, TotemFinder consists of three interfaces to help refine classification results and analyze shared objects between candidates to find the totem:

- Interface #1 (Fig. 1) enables efficient verification of the base image classification results as correct/incorrect.
- Interface #2 (Fig. 2) enables updating incorrectly classified objects to be correct.
- Interface #3 (Fig. 3) enables visual analytics to identify key players based on shared objects in their social media pictures.

In essence, the workflow consists of two phases: Interfaces #1 and #2 are used to correct image classification results. In Interface #1, the user

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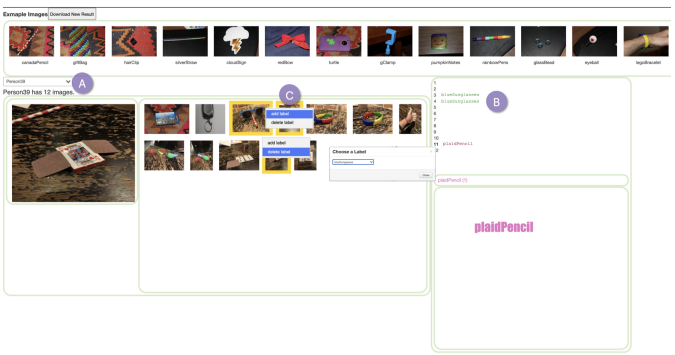

Fig. 2. Interface #2 supports re-labeling incorrect object predictions.

Fig. 3. Interface #3 provides several coordinated views to support key player identification based on shared objects in their image collections.

batch marks predictions as correct/incorrect using a design inspired by image identification reCAPTCHA [2]. Objects marked incorrect in this interface are then manually batch updated in Interface #2 to be correct. In the second phase, Interface #3 displays these distilled results with coordinated visualizations to enable the user identify groups of people based on shared objects that appear in their social media posts.

2 TotemFinder

TotemFinder takes as input social media data for a collection of persons. The social media data for each person consists of a set of images where each image optionally has an attached text caption. Each image file also has an associated list of objects that have been extracted from the image based on application of a pre-trained image classifier, where each object has a name, the object's location in the image (a bounding box), and the classifier's confidence in that result. The image dataset for the second Mini Challenge contains 4,412 predictions (43 object classes) for 907 total images.

2.1 Interface # 1

Interface #1, shown in Fig. 1, visualizes the initial set of predictions using beeswarm charts. (A) Each beeswarm chart represents a predicted class (an object). Each of the 4,412 predictions is rendered using a circle and placed in the appropriate beeswarm plot with vertical position representing the classifier's confidence score in that result. Object classes with no initial predictions had no beeswarm drawn their space (hence the gaps in Fig 1). Predictions were initially colored using a categorical palette of "neutral" colors for each beeswarm.

To verify the classifier's object predictions, we implement a design inspired by image identification reCAPTCHA which quickly lets the user select a set of predictions and batch label them as correct/incorrect. To do this, the user clicks (B) a beeswarm's reference image to open all prediction images for that class, ordered by decreasing confidence score. (C) The user scans the images and clicks ones that are correctly classified, which turns their borders to a green color to indicate a correctly identified object. If needed, hovering on an image highlights it in the beeswarm and (D) shows a magnified version for detailed review. (E) When all correct images are clicked, a submit button batch labels them as "correct," and all other prediction images for the object are labeled "incorrect."

2.2 Interface # 2

Predictions labeled as incorrect in Interface #1 are updated in Interface #2 to the correct object. (Alternatively, incorrect predictions can be deleted, or missed objects that were not classified at all can be added.) Fig. 2 shows the workflow. (A) The user load the images for a selected person. (B) At right, class labels are shown for each image either as green (correct) or red (incorrect). (C) Clicking an image selects it and lets the user update or add to its object labels. As in Interface #1, multiple images can be selected and processed in batch.

Upon completing this relabeling process, every image is assumed correctly labeled with no uncertainty (based on user review) and we have a complete network of person-object affiliations (the object is affiliated if it shows up in at least one picture for a person).

3 Interface #3

The distilled network of person-data affiliations is analyzed using Interface #3 (shown in Fig. 3). Specifically, subnetworks of key players for specific items (such as the totem) can be filtered and analyzed.

The primary visualization is (A) an ontology node-link diagram, where nodes are either persons (blue) and objects (gold). An edge between a person and object indicates an affiliation: the person has that object in at least one of their images. Edge width encodes the affiliation significance, measured as $\frac{Number\ of\ Images\ With\ The\ Object}{Total\ Images}$. The ontology graph supports filtering: person nodes can be hovered on to highlight other persons that share objects, object nodes can be hovered to show people having that object, and slider bars can filter people/edges based on min/max thresholds (e.g., a person must have a minimum number of objects to be shown).

Above, (B) a bar chart shows the number of people affiliated with each object. (C) An adjacency matrix encodes affiliation similarity between people. Clicking a person's label sorts the matrix rows and columns based on the number of shared affiliations. This enables us to clearly see the subgroup cliques each person is associated with. When a object is selected in the ontology graph or the bar chart, (F) an image gallery for that object populates, showing all the images and captions for people affiliated with that object.

4 Conclusion

This paper presents TotemFinder, an interactive visualization tool designed and developed for the VAST 2020 Mini-Challenge 2. A demo video showing theTotemFinder's interactive workflow may be found at `https://vimeo.com/438081158`. The codebase is open source and may be downloaded at `https://github.com/JakobWong/VAST2020`.

TotemFinder's design proposes a human-in-the-loop workflow, with an emphasis on the efficient human verification of model predictions and relabeling of incorrect results. The quality of the totem analysis and identification depends on the performance of this oversight process (e.g., mistakes in the distilled dataset can deceive the analyst's final analyses). Future work can incorporate additional cross-checks to help affirm the validity of the distilled dataset.

References

[1] IEEE VAST Challenge 2020, Mini Challenge 2. `https://vast-challenge.github.io/2020/MC2.html`.

[2] V. Shet. Are you a robot? introducing no captcha recaptcha. *Google Security Blog*, 3:12, 2014.