AI Based Opto-Lexical Pattern Analysis for Behavior Classification

Akshath Jain
North Allegheny Senior High School

90%

of all terrorist communication happens through social media

Background

Social media has 4 main purposes for terrorist groups:

1. Share operational and tactical information
2. Gateway to other online radical content
3. Media outlet for terrorist propaganda
4. Remote reconnaissance for targeting purposes

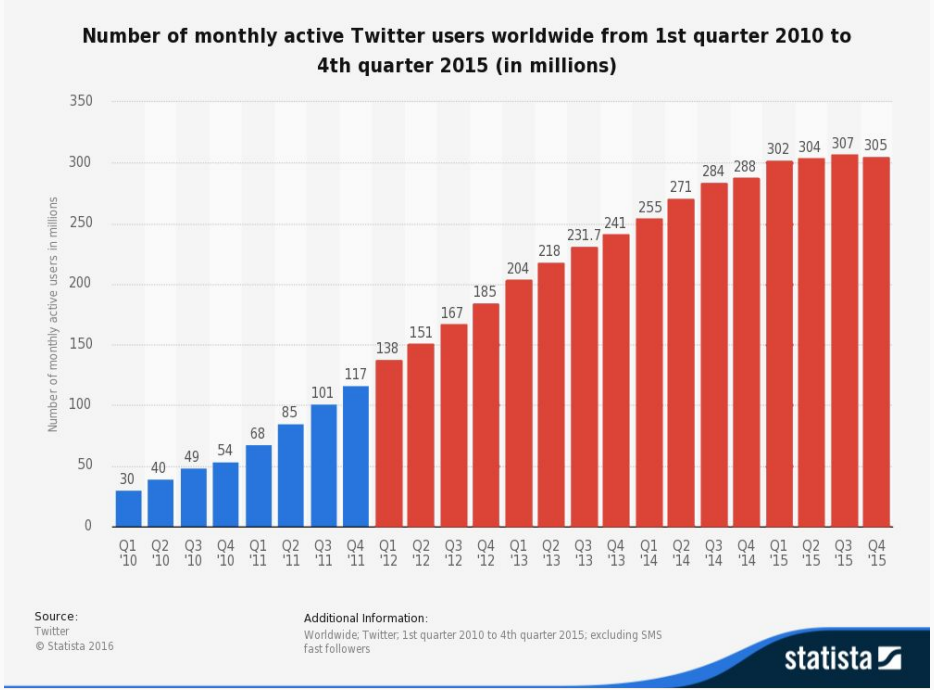
Twitter is the platform on which most of this occurs.

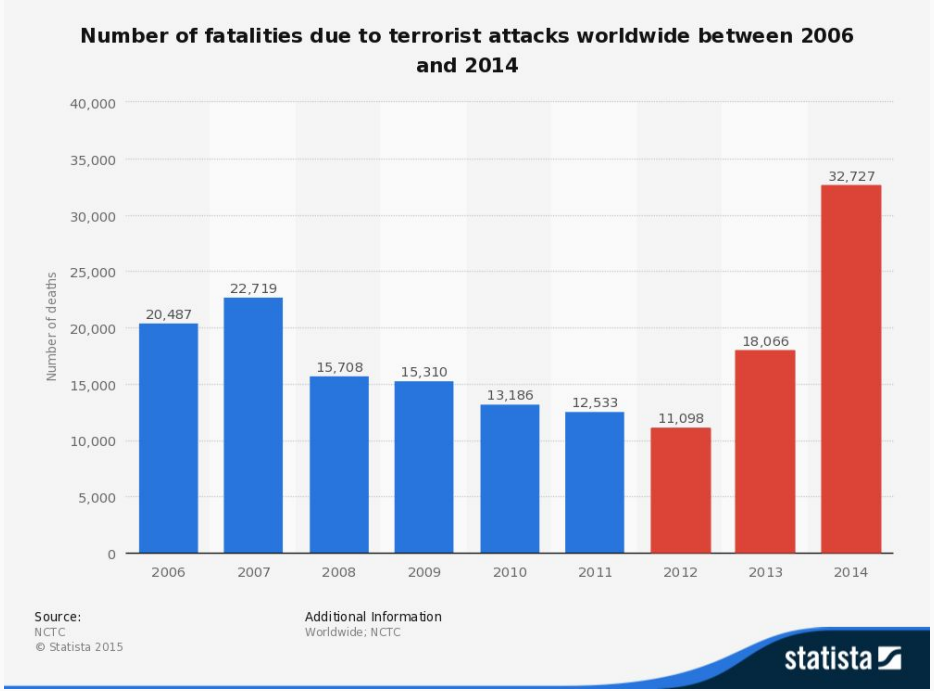
- Microblogging site
- Active user base of 300 million

There are an estimated 90,000 terrorist accounts on Twitter (0.03%).

Background

An increase in Twitter users is correlated with an increase in terrorist attacks.





Analyzing social media feeds with machine learning algorithms can classify behavioral patterns

Algorithm

A simple 3 step process ensures optimal efficiency within the program.

Twitter Account Data Collection

Data Parsing

Data Analysis & Prediction

Methodology

The 27 parameters used to ensure minimal false-positives.

Diction

- Word choice/frequency
- Percent match
- Average match distribution
- Hashtags

Affiliation to Known Accounts

- Friends
- Followers
- Retweets
- Content mentions

Miscellaneous

- Date
- Time/Time Zone
- Number of tweets per day
- Location
- Language

Visual Media

- Adult Score
- Racy Score
- Autogenerated image caption
- Number of males
- Number of females
- Number of faces
- Average age
- Width
- Height
- Foreground color
- Background color
- Blaw and white status
- Clipart status
- Vector-style status

Code Sample

ImageObject.java

```java
/*
Name: Akshath Jain
Date: 12/27/16 - 12/28/16
Purpose: Image Object java that stores an image, the object
*/

/*
example of json output:
{"adult":{"isAdultContent":false,"isRacyContent":false,"adu
{"adult":{"isAdultContent":false,"isRacyContent":false,"adu

*/

import org.apache.http.HttpEntity;
import org.apache.http.HttpResponse;
import org.apache.http.client.HttpClient;
import org.apache.http.client.methods.HttpPost;
import org.apache.http.client.utils.URIBuilder;
import org.apache.http.entity.StringEntity;
import org.apache.http.impl.client.HttpClients;
import org.apache.http.util.EntityUtils;

import java.net.URI;

import org.json.*;

public class ImageObject {
    private double adultScore;
    private double racyScore;
    private Wordlist tags;
    private int numMales;
    private int numFemales;
    private int numFaces;
    private double averageAge;
    private int width;
    private int height;
    private int dominantColorForeground;
    private int dominantColorBackground;
    private int isBlackAndWhite; //0 for false, 1 for true
    private static final int WHITE = 1000;
    private static final int BLACK = 1001;
    private static final int RED = 1002;
    private static final int ORANGE = 1003;
    private static final int YELLOW = 1004;
    private static final int GREEN = 1005;
    private static final int BLUE = 1006;
    private static final int CYAN = 1007;
    private static final int INDIGO = 1008;
    private static final int VIOLET = 1009;
    private static final int BROWN = 1010;
    private static final int GREY = 1011; //check for grey
    private int clipArtType; //0 = nonclipart, 1 = ambiguou
    private int lineDrawingType; //0 = non-line drawing; 1

    private ImageObject(){}

    public ImageObject(String url) {
        String information = null; //information about image collected from the api

        //make a call upon Microsoft Vision API
        HttpClient httpClient = HttpClients.createDefault();
        try {
            URIBuilder builder = new URIBuilder("https://api.projectoxford.ai/vision/v1.0/
            builder.setParameter("visualFeatures", "Tags,Description,Faces,ImageType,Color

            URI uri = builder.build();
            HttpPost request = new HttpPost(uri);
            request.setHeader("Content-Type", "application/json");
            request.setHeader("Ocp-Apim-Subscription-Key", "APPLICATION KEY NOT SHOWN FOR

            StringEntity reqEntity = new StringEntity("{\'url\':\'" + url + "\'}");
            request.setEntity(reqEntity);

            HttpResponse response = httpClient.execute(request);
            HttpEntity entity = response.getEntity();

            if (entity != null)
                information = EntityUtils.toString(entity);
        } catch (Exception e) {
            e.printStackTrace();
        }

        System.out.println(information);
        //parse json and use returned object to assign data to this object
        ImageObject tempObj = parseFromJSONString(information);
        this.adultScore = tempObj.adultScore;
        this.racyScore = tempObj.racyScore;
        this.tags = tempObj.tags;
        this.numMales = tempObj.numMales;
        this.numFemales = tempObj.numFemales;
        this.numFaces = tempObj.numFaces;
        this.averageAge = tempObj.averageAge;
        this.width = tempObj.width;
        this.height = tempObj.height;
        this.dominantColorForeground = tempObj.dominantColorForeground;
        this.dominantColorBackground = tempObj.dominantColorBackground;
        this.isBlackAndWhite = tempObj.isBlackAndWhite;
        this.clipArtType = tempObj.clipArtType;
        this.lineDrawingType = tempObj.lineDrawingType;
    }

    //parses JSON data to respective formats
    public static ImageObject parseFromJSONString(String info){
```

ImageObject.java

```java
    //parses JSON data to respective formats
    public static ImageObject parseFromJSONString(String info){
        ImageObject objToReturn = new ImageObject();

        JSONObject parser = new JSONObject(info);

        //get adult and racy score
        JSONObject adult = parser.getJSONObject("adult");
        if(adult != null){
            if(adult.optString("adultScore") != null)
                objToReturn.adultScore = Double.parseDouble(adult.optString("adultScore", "-1"));

            if(adult.optString("racyScore") != null)
                objToReturn.racyScore = Double.parseDouble(adult.optString("racyScore", "-1"));
        }else{
            objToReturn.adultScore = -1;
            objToReturn.racyScore = -1;
        }

        //get tags
        JSONObject description = parser.optJSONObject("description");
        if(description != null){
            //get tags from picture and add to wordlist tags
            JSONArray jsontags = description.optJSONArray("tags");
            if(jsontags != null){
                String[] t = new String[jsontags.length()];
                for(int i = 0; i < jsontags.length(); i++)
                    t[i] = jsontags.optString(i);

                objToReturn.tags = new Wordlist(t);
            }else{
                objToReturn.tags = null;
            }

            //get caption from image and add to wordlist tags
            JSONArray jsoncaptions = description.optJSONArray("captions");
            if(jsoncaptions != null){
                String captionText = "";
                for(int i = 0; i < jsoncaptions.length(); i++){
                    JSONObject tempObj = jsoncaptions.optJSONObject(i);
                    if(tempObj != null)
                        captionText += tempObj.optString("text");
                }
                objToReturn.tags.add(captionText.split(" "));
            }
        }else{
            objToReturn.tags = null;
        }

        //get number of males, number of females, number of faces, and average age
        JSONArray faces = parser.optJSONArray("faces");
        if(faces != null){
```

Code Sample

```
        //get number of males, number of females, number of faces, and average age
        JSONArray faces = parser.optJSONArray("faces");
        if(faces != null){
            objToReturn.numFaces = faces.length();
            for(int i = 0; i < faces.length(); i++){
                JSONObject tempObj = faces.optJSONObject(i);
                if(tempObj != null){
                    objToReturn.averageAge += tempObj.optInt("age", 0);
                    if(tempObj.optString("gender").equals("Male"))
                        objToReturn.numMales++;
                    else
                        objToReturn.numFemales++;
                }
            }
            if(faces.length() != 0)
                objToReturn.averageAge = objToReturn.averageAge/faces.length();
            else
                objToReturn.averageAge = 0;
        }else{
            objToReturn.averageAge = 0;
            objToReturn.numMales = 0;
            objToReturn.numFemales = 0;
            objToReturn.numFaces = 0;
        }

        //get width and height
        JSONObject metadata = parser.optJSONObject("metadata");
        if(metadata != null){
            objToReturn.width = metadata.optInt("width", 0);
            objToReturn.height = metadata.optInt("height", 0);
        }else{
            objToReturn.width = 0;
            objToReturn.height = 0;
        }

        //get dominant color foreground and background
        JSONObject color = parser.optJSONObject("color");
        if(color != null){
            String[] field = new String[]{"dominantColorForeground", "dominantColo

            String tempBW = color.optString("isBWImg");
            if(tempBW.equals("true"))
                objToReturn.isBlackAndWhite = 1;
            else if(tempBW.equals("false"))
                objToReturn.isBlackAndWhite = 0;
            else
                objToReturn.isBlackAndWhite = -1;

            for(int i = 0; i < 2; i++){
                String tempColorString = color.optString(field[i]);
                int tempColorInt;
                switch(tempColorString){
                    case "White":
```

```
            for(int i = 0; i < 2; i++){
                String tempColorString = color.optString(field[i]);
                int tempColorInt;
                switch(tempColorString){
                    case "White":
                        tempColorInt = WHITE;
                        break;
                    case "Black":
                        tempColorInt = BLACK;
                        break;
                    case "Red":
                        tempColorInt = RED;
                        break;
                    case "Orange":
                        tempColorInt = ORANGE;
                        break;
                    case "Yellow":
                        tempColorInt = YELLOW;
                        break;
                    case "Green":
                        tempColorInt = GREEN;
                        break;
                    case "Blue":
                        tempColorInt = BLUE;
                        break;
                    case "Cyan":
                        tempColorInt = CYAN;
                        break;
                    case "Indigo":
                        tempColorInt = INDIGO;
                        break;
                    case "Violet":
                        tempColorInt = VIOLET;
                        break;
                    case "Brown":
                        tempColorInt = BROWN;
                        break;
                    case "Grey":
                        tempColorInt = GREY;
                        break;
                    case "Gray":
                        tempColorInt = GREY;
                        break;
                    default:
                        tempColorInt = -1;
                        break;
                }
                if(i == 0){
                    objToReturn.dominantColorForeground = tempColorInt;
                }else{
                    objToReturn.dominantColorBackground = tempColorInt;
                }
```

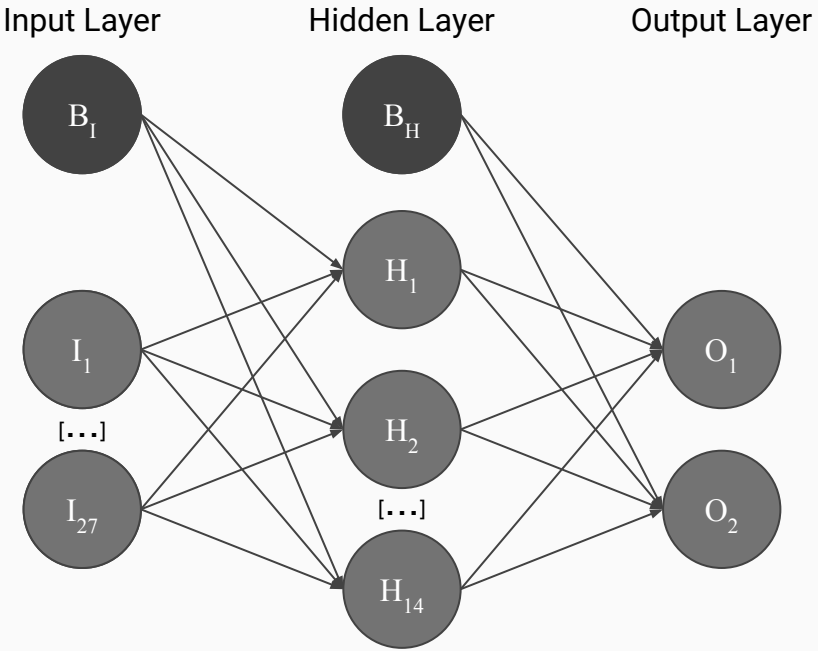
```
            }else{
                objToReturn.dominantColorBackground = -1;
                objToReturn.dominantColorForeground = -1;
                objToReturn.isBlackAndWhite = -1;
            }

            //get clipart type and line drawing type
            JSONObject imageType = parser.optJSONObject("imageType");
            if(imageType != null){
                objToReturn.lineDrawingType = imageType.optInt("lineDrawingType", -1);
                objToReturn.clipArtType = imageType.optInt("clipArtType", -1);
            }else{
                objToReturn.lineDrawingType = -1;
                objToReturn.clipArtType = -1;
            }

            return objToReturn;
        }

        public String toString(){
            return "adultScore: " + adultScore +
                "\nracyScore: " + racyScore +
                "\ntags: " + tags.toString() +
                "\nnumMales: " + numMales +
                "\nnumFemales: " + numFemales +
                "\nnumFaces: " + numFaces +
                "\naverageAge: " + averageAge +
                "\nwidth: " + width +
                "\nheight: " + height +
                "\ndominantColorForeground: " + dominantColorForeground +
                "\ndominantColorBackground: " + dominantColorBackground +
                "\nisBlackAndWhite: " + isBlackAndWhite +
                "\nlineDrawingType: " + lineDrawingType +
                "\nclipArtType: " + clipArtType;
        }

        public double getAdultScore() {
            return adultScore;
        }

        public double getRacyScore() {
            return racyScore;
        }

        public WordList getTags() {
            return tags;
        }

        public int getNumMales() {
            return numMales;
        }
```

Code Sample

```
300     public int getNumMales() {
301         return numMales;
302     }
303
304     public int getNumFemales() {
305         return numFemales;
306     }
307
308     public int getNumFaces() {
309         return numFaces;
310     }
311
312     public double getAverageAge() {
313         return averageAge;
314     }
315
316     public int getWidth() {
317         return width;
318     }
319
320     public int getHeight() {
321         return height;
322     }
323
324     public int getDominantColorForeground() {
325         return dominantColorForeground;
326     }
327
328     public int getDominantColorBackground() {
329         return dominantColorBackground;
330     }
331
332     public int getIsBlackAndWhite() {
333         return isBlackAndWhite;
334     }
335
336     public int getClipArtType() {
337         return clipArtType;
338     }
339
340     public int getLineDrawingType() {
341         return lineDrawingType;
342     }
343 }
```

Prediction Algorithm

Neural Network Diagram

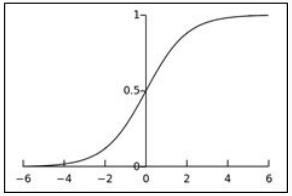


Regular Usage

$$H_j = \sigma\left(w_{B_I H_j} + \sum_{i=1}^{14} I_n w_{I_i H_j}\right)$$

$$O_k = \sigma\left(w_{B_H O_k} + \sum_{j=1}^{2} H_j w_{H_j O_k}\right)$$

$$\sigma(s) = \frac{1}{1 + e^{-s}}$$



Network Training

$$\delta O_k = O_k(E)\left(1 - O_k(E)\right)\left(T_k(E) - O_k(E)\right)$$

$$\delta H_j = H_j(E)\left(1 - H_j(E)\right)\sum_{k=1}^{2} w_{H_j O_k}\delta O_k$$

$$\Delta w_{I_i H_j} = \eta I_i(E)\delta H_j$$

$$\Delta w_{H_j O_k} = \eta H_j(E)\delta O_k$$

Neural Network Code Sample

NeuralNetwork.java

```java

    public int classify(TwitterAccount account) {
        //initializes input layer
        WordList textData = account.getTextData(); //contains diction data
        ImageList imageData = account.getTextData(); //contains visual media data
        double[] misc = account.getMisc(); //contains affiliation and misc data
        textData.fillInputLayer(inputLayer, 1, 1 + textData.numParams());
        imageData.fillInputLayer(inputLayer, 2 + textData.numParams(), 2 + textData.numParams() + imageData.numParams());
        for(int i = 0; i < misc.length; i++)
            inputLayer[i + 3 + textData.numParams() + imageData.numParams()] = misc[i];

        //initializes input layer
        double[] temp = account.getDiction();
        for (int i = 1; i <= 3; i++)
            inputLayer[i] = temp[i - 1];
        inputLayer[4] = account.getAffiliation();

        //set hidden layer values
        for (int j = 1; j < numHiddenNodes; j++) {
            double sum = 0;
            for (int i = 0; i < numInputNodes; i++)
                sum += inputLayer[i] * wIH[i][j];

            hiddenLayer[j] = sigmoid(sum);
        }

        //set output layer values
        for (int k = 0; k < numOutputNodes; k++) {
            double sum = 0;
            for (int j = 0; j < numHiddenNodes; j++)
                sum += hiddenLayer[j] * wHO[j][k];

            outputLayer[k] = sigmoid(sum);
        }

        //determine account
        if (outputLayer[0] > outputLayer[1]) //the first node: is a match; second node: not a match
            return 1; //account is a match
        else
            return 0; //account isn't a match
    }
```

Experimentation

Methodology

A two step process to train and test the prediction algorithm.

Neural Network Training

- Supervised learning with sample data
- Computer “learns” patterns

Testing

- Sample data set used
  - Precompiled data set of known hostile accounts
  - Contains images, text, media, etc

Overview

Training

- Training set (120 total)
  - 12 positive
  - 108 negative
- Validation set used to prevent overfitting (120 total)
  - 12 positive
  - 108 negative

Testing

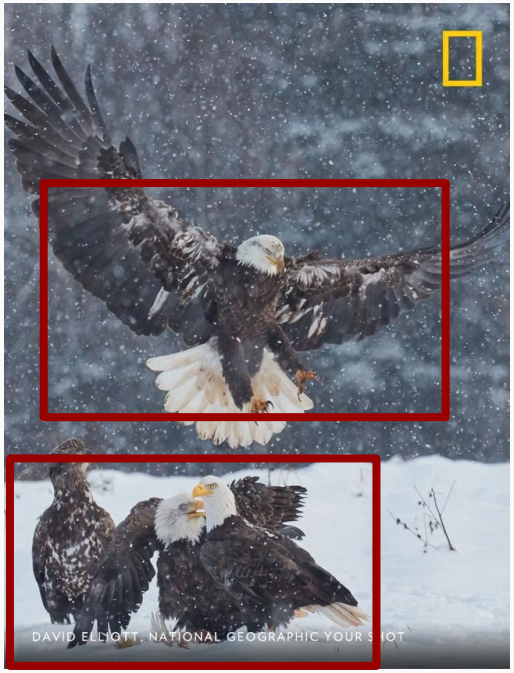
- Trial 1: (64 total)
  - Core accounts (1.0%)
- Trials 2 - 9: Negative accounts from different categories (6,336 total)
  - Brands and Products (2.50%)
  - Companies and Organizations (2.50%)
  - Local Businesses (0.05%)
  - Movies (0.95%)
  - Music (4.73%)
  - Sports (2.03%)
  - Television (0.23%)
  - Websites (1.57%)
  - People (85.44%)

Results/Analysis

84%

accurate in correctly classifying terrorist accounts

Visual Media Analysis Sample #1



Auto-generated caption: *"a group of birds sitting in the snow"*

Source: @NatGeoPhotos

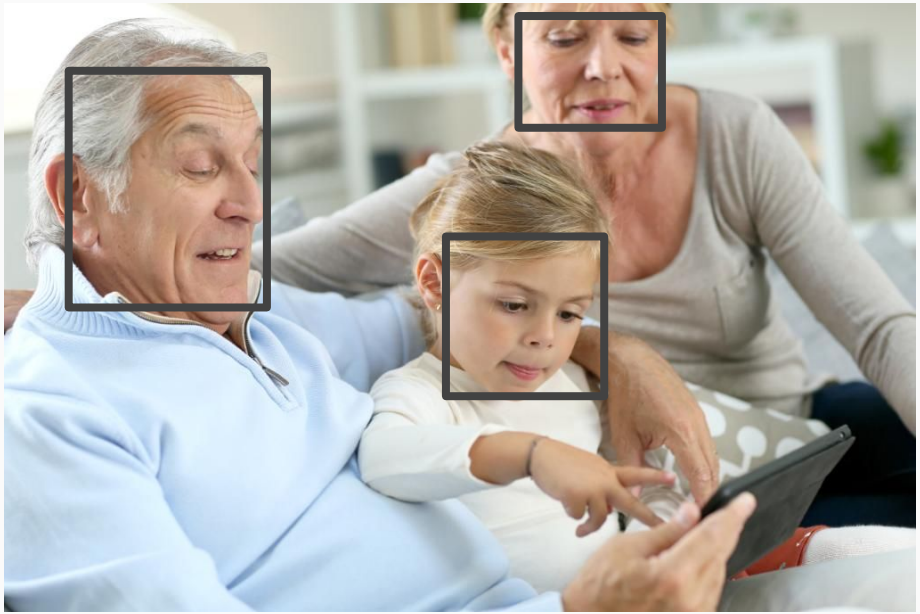
Metadata

- Height: *864*
- Width: *648*
- Prominent foreground color: *grey*
- Prominent background color: *grey*

Description

"fish", "animal", "water", "snow", "sitting", "table", "man", "top", "boat", "bird", "large", "standing", "blue", "parked", "air", "skiing", "ocean", "white", "laying", "group", "people", "riding", "playing", "cat", "beach"

Visual Media Analysis Sample #2



Auto-generated caption: *"a man with a computer holding a little girl"*

Source: @Forbes

Metadata

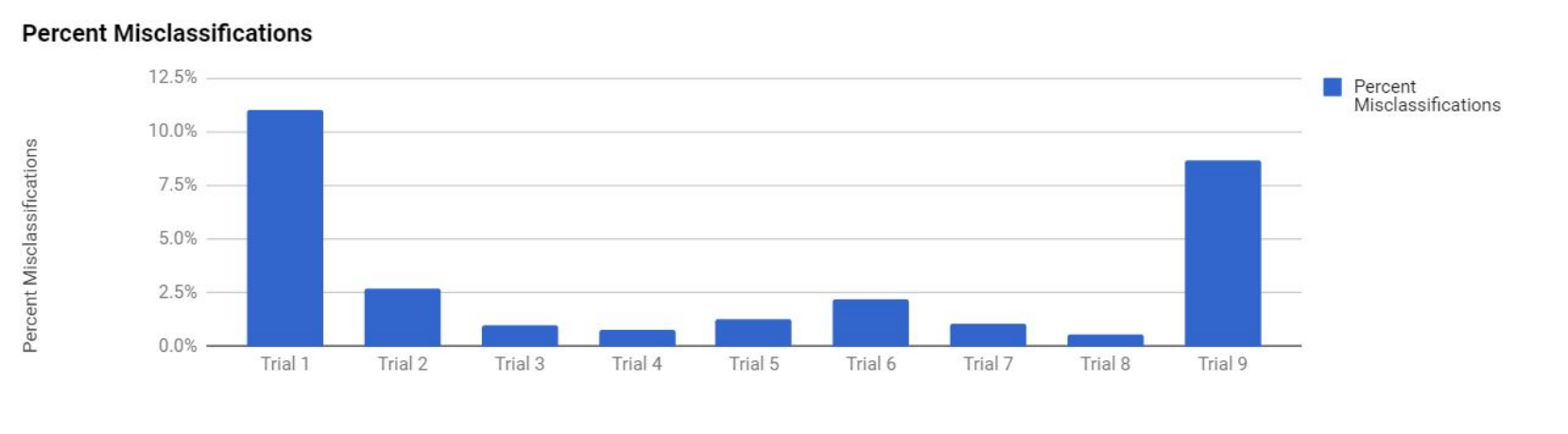
- Height: *683*
- Width: *1024*
- Male: *1, age 70*
- Females: *2, ages 6 and 55*
- Prominent foreground color: *white*
- Prominent background color: *white*

Description

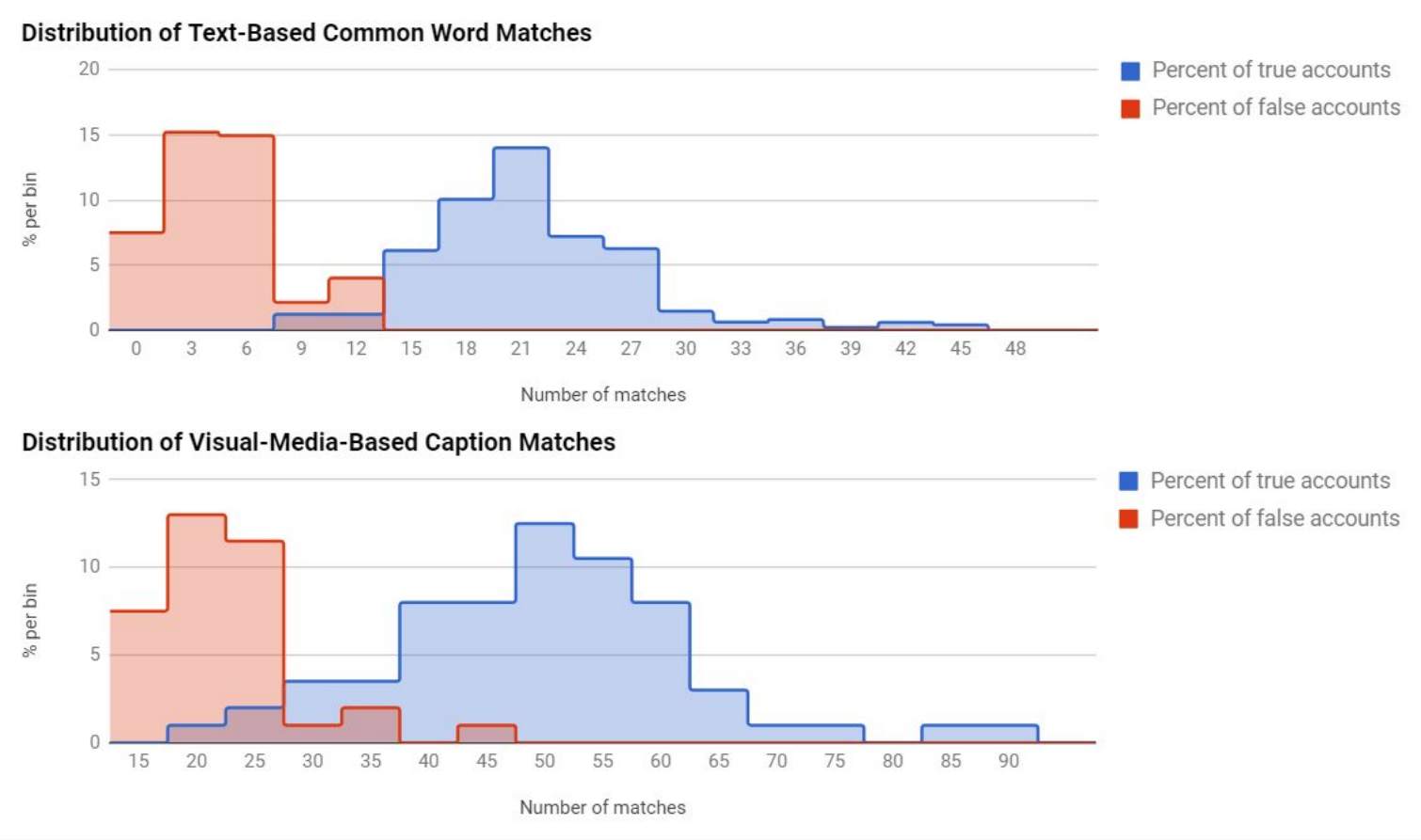
"Person", "sitting", "man", "table", "looking", "holding", "laptop", "older", "people", "using", "computer", "woman", "baby", "food", "playing", "young", "white", "player", "room", "group", "phone"

Analysis

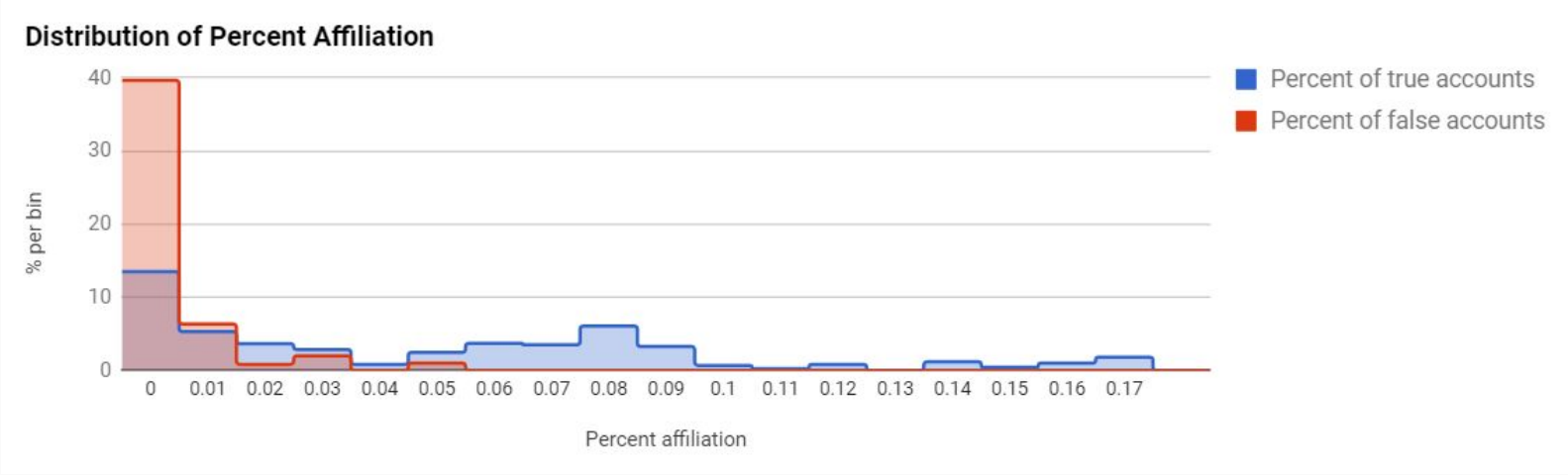
	True Accounts	False Accounts							
	Trial 1: Hostile	Trial 2: Brands and Products	Trial 3: Companies and Organizations	Trial 4: Local Businesses	Trial 5: Movies and Television	Trial 6: Music	Trial 7: Sports	Trial 8: Websites	Trial 9: Individual
Percent Misclassifications	11.0%	2.7%	1.0%	0.8%	1.3%	2.2%	1.1%	0.6%	8.7%



Analysis


Distribution of Text-Based Common Word Matches
Percent of true accounts
Percent of false accounts
% per bin
20
15
10
5
0
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
Number of matches
Distribution of Visual-Media-Based Caption Matches
Percent of true accounts
Percent of false accounts
% per bin
15
10
5
0
15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
Number of matches

Analysis


Distribution of Percent Affiliation
Percent of true accounts
Percent of false accounts
% per bin
40
30
20
10
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
0.13
0.14
0.15
0.16
0.17
Percent affiliation

Conclusion

Overview

Hypothesis was correct:

- Analyzing social media feeds with machine learning algorithms can classify behavioral patterns

Experiment was successful

- National Institute of Justice: “Success rates are based on the consequences of errors”
- 84% accurate in identifying accounts
- False positive rates show areas for improvement

Plans for Improvement

Ameliorations to my project for its betterment.

Expand Analysis Platforms

- Other types of social media
- More analysis parameters

Test Using a Larger Sample Size

Enhance Efficiency

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