# Deep Sentiment Analysis on Tumblr

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A dissertation submitted in partial fulfilment
of the requirements for the degree of
Master of Science in Applied Statistics

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# Declaration

The work in this thesis is based on research carried out at the Department of Statistics, University of Oxford. No part of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text.

# Acknowledgements

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## Abstract

This thesis proposes a novel approach to sentiment analysis using deep neural networks on both images and text.

# Contents

# List of Figures

# List of Tables

# Chapter 1

# Introduction

# Chapter 2

# Tumblr data

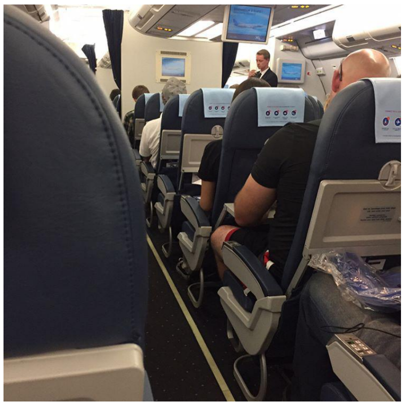
## 2.1 Overview of the data

Tumblr's posts were extracted using the official API thanks to their tags that were taken as the ground truth. The tags represent the user's emotion: happy, sad, angry, surprised, scared or disgusted. The data extraction took several weeks due to the API's limitations: 1,000 requests per hour and 5,000 requests per day, with each request containing 20 posts. The final dataset has about one million posts and six different emotions.

Need to talk about preprocessing non-english posts

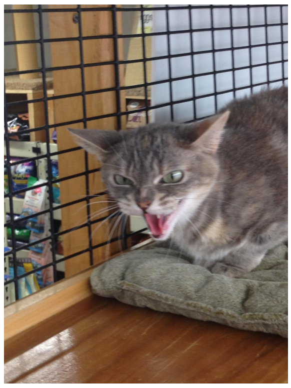
Here are examples of posts with their associated emotions:

(a) **Happy**: "Just relax with this amazing view #bigsur #california #roadtrip #usa #life #fitness (at McWay Falls)"

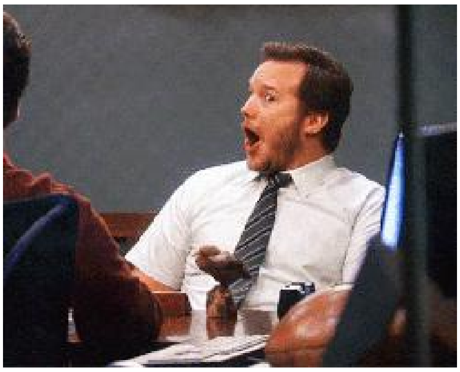


(b) **Scared**: "On a plane guys! We're about to head out into the sky to Paris, France #Paris #trip #kinda #nervous #fun #vacations"


(c) **Sad**: "It's okay to be upset. It's okay to not always be happy. It's okay to cry. Never hide your emotions in fear of upsetting others or of being a bother If you think no one will listen. Then I will."



(d) **Angry**: "Tensions were high this Caturday..."



(e) **Surprised**: "Which Tea? Peppermint tea: What is your favorite gif right now?"

(f) **Disgusted**: "Me when I see a couple expressing their affection in physical ways in public"

Figure 2.1: Some examples of Tumblr posts

# Chapter 3

# Visual recognition

## 3.1 Section 1

# Chapter 4

# Natural Language Processing

Text analysis

## 4.1 Section 1

# Chapter 5

# Recurrent Neural Networks for text generation

## 5.1 Section 1

# Chapter 6

# Useful maths in LaTeX

## 6.1 Equations related

$$\frac{\partial u_1}{\partial t} = \Delta w_1 \quad \text{in } \ \Omega, t > 0, \tag{6.1}$$

$$\frac{\partial u_2}{\partial t} = \Delta w_2 \quad \text{in } \ \Omega, t > 0, \tag{6.2}$$

where

$$w_1 = \frac{\delta F(u_1, u_2)}{\delta u_1}, \tag{6.3}$$

$$w_2 = \frac{\delta F(u_1, u_2)}{\delta u_2}, \tag{6.4}$$

$$\begin{aligned} F(u_1, u_2) &= b_1 u_1^4 - a_1 u_1^2 + c_1 |\nabla u_1|^2 \\ &\quad + b_2 u_2^4 - a_2 u_2^2 + c_2 |\nabla u_2|^2 \\ &\quad + D \left( u_1 + \sqrt{\frac{a_1}{2b_1}} \right)^2 \left( u_2 + \sqrt{\frac{a_2}{2b_2}} \right)^2 . \end{aligned} \tag{6.5}$$

$$U_1^n = \sum_{i=1}^{J} U_{1,i}^n \eta_i, \quad W_1^n = \sum_{i=1}^{J} W_{1,i}^n \eta_i, \tag{6.6}$$

$$U_2^n = \sum_{i=1}^{J} U_{2,i}^n \eta_i, \quad W_2^n = \sum_{i=1}^{J} W_{2,i}^n \eta_i, \tag{6.7}$$

We also use the following notation, for $1 \le q < \infty$,

$$L^q(0,T;W^{m,p}(\Omega)) := \left\{ \eta(x,t) :\ \eta(\cdot,t) \in W^{m,p}(\Omega), \int_0^T \|\eta(\cdot,t)\|^q_{m,p}\, dt < \infty \right\},$$
$$L^\infty(0,T;W^{m,p}(\Omega)) := \left\{ \eta(x,t) : \eta(\cdot,t) \in W^{m,p}(\Omega),\ \operatorname*{ess\,sup}_{t\in(0,T)} \|\eta(\cdot,t)\|_{m,p} < \infty \right\},$$

Cases

$$|v|_{0,r} \le C|v|^{1-\mu}_{0,p}\|v\|^{\mu}_{m,p}, \quad \text{holds for } r \in \begin{cases} [p,\infty] & \text{if } m - \frac{d}{p} > 0, \\ [p,\infty) & \text{if } m - \frac{d}{p} = 0, \\ [p, -\frac{d}{m-d/p}] & \text{if } m - \frac{d}{p} < 0. \end{cases} \tag{6.8}$$

## 6.2 Writing

**Lemma 6.2.1** Let $u, v, \eta \in H^1(\Omega)$, $f = u - v$, $g = u^m v^{n-m}$, $m, n = 0, 1, 2$, and $n - m \ge 0$. Then for $d = 1, 2, 3$,

$$\left| \int_\Omega fg\eta dx \right| \le C|u-v|_0\ \|u\|_1^m\ \|v\|_1^{n-m}\ \|\eta\|_1. \tag{6.9}$$

**Proof**: Note that using the Cauchy-Schwarz inequality we have

$$|(u)^m v^{n-m}|_{0,p} \le \begin{cases} |u|^m_{0,2mp}\ |v|^{(n-m)}_{0,2(n-m)p} & \text{for } \ n-m \ne 0, \ \text{ and } \ m \ne 0, \\ |u|^m_{0,mp} \ \text{ or } \ |v|^{(n-m)}_{0,(n-m)p} & \text{for } \ m = 0, \ \text{ or } \ n-m = 0 \ \text{ respectively.} \end{cases}$$

Noting the generalise Hölder inequality and the result above we have

$$\begin{aligned} \left| \int_\Omega fg\eta dx \right| &\le |u-v|_0\ |u^m v^{n-m}|_{0,3}\ |\eta|_{0,6}, \\ &\le |u-v|_0 \ \ |\eta|_{0,6} \begin{cases} |u|^2_{0,6} & \text{for } \ m = 2, \\ |u|_{0,6}\ |v|_{0,6} & \text{for } \ m = 1, \\ |v|^2_{0,6} & \text{for } \ m = 0, \end{cases} \\ &\le C|u-v|_0\ \|u\|_1^m\ \|v\|_1^{n-m}\ \|\eta\|_1, \end{aligned}$$

where we have noted (6.8) to obtain the last inequality. This ends the proof. $\square$

We consider the problem:

(**P**) Find $\{u_i, w_i\}$ such that $u_i \in H^1(0,T;(H^1(\Omega))') \cap L^\infty(0,T;H^1(\Omega))$ for *a.e.* $t \in (0,T)$, $w_i \in L^2(0,T;H^1(\Omega))$

$$\left\langle \frac{\partial u_1}{\partial t}, \eta \right\rangle$$

# Chapter 7

# Conclusions

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# Appendix A

# Basic and Auxiliary Results

## A.1 Basic Results