
Practical Natural Language Processing

*A Comprehensive Guide to Building
Real-World NLP Systems*

*Sowmya Vajjala, Bodhisattwa Majumder,
Anuj Gupta, and Harshit Surana*

Beijing • Boston • Farnham • Sebastopol • Tokyo

O'REILLY®

Table of Contents

Foreword.....	xv
----------------------	-----------

Preface.....	xvii
---------------------	-------------

Part I. Foundations

1. NLP: A Primer.....	3
NLP in the Real World	5
NLP Tasks	6
What Is Language?	8
Building Blocks of Language	9
Why Is NLP Challenging?	12
Machine Learning, Deep Learning, and NLP: An Overview	14
Approaches to NLP	16
Heuristics-Based NLP	16
Machine Learning for NLP	19
Deep Learning for NLP	22
Why Deep Learning Is Not Yet the Silver Bullet for NLP	28
An NLP Walkthrough: Conversational Agents	31
Wrapping Up	33
2. NLP Pipeline.....	37
Data Acquisition	39
Text Extraction and Cleanup	42
HTML Parsing and Cleanup	44
Unicode Normalization	45
Spelling Correction	46

System-Specific Error Correction	47
Pre-Processing	49
Preliminaries	50
Frequent Steps	52
Other Pre-Processing Steps	55
Advanced Processing	57
Feature Engineering	60
Classical NLP/ML Pipeline	62
DL Pipeline	62
Modeling	62
Start with Simple Heuristics	63
Building Your Model	64
Building THE Model	65
Evaluation	68
Intrinsic Evaluation	68
Extrinsic Evaluation	71
Post-Modeling Phases	72
Deployment	72
Monitoring	72
Model Updating	73
Working with Other Languages	73
Case Study	74
Wrapping Up	76
3. Text Representation.....	81
Vector Space Models	84
Basic Vectorization Approaches	85
One-Hot Encoding	85
Bag of Words	87
Bag of N-Grams	89
TF-IDF	90
Distributed Representations	92
Word Embeddings	94
Going Beyond Words	103
Distributed Representations Beyond Words and Characters	105
Universal Text Representations	107
Visualizing Embeddings	108
Handcrafted Feature Representations	112
Wrapping Up	113

Part II. Essentials

4. Text Classification.....	119
Applications	121
A Pipeline for Building Text Classification Systems	123
A Simple Classifier Without the Text Classification Pipeline	125
Using Existing Text Classification APIs	126
One Pipeline, Many Classifiers	126
Naive Bayes Classifier	127
Logistic Regression	131
Support Vector Machine	132
Using Neural Embeddings in Text Classification	134
Word Embeddings	134
Subword Embeddings and fastText	136
Document Embeddings	138
Deep Learning for Text Classification	140
CNNs for Text Classification	143
LSTMs for Text Classification	144
Text Classification with Large, Pre-Trained Language Models	145
Interpreting Text Classification Models	147
Explaining Classifier Predictions with Lime	148
Learning with No or Less Data and Adapting to New Domains	149
No Training Data	149
Less Training Data: Active Learning and Domain Adaptation	150
Case Study: Corporate Ticketing	152
Practical Advice	155
Wrapping Up	157
 5. Information Extraction.....	 161
IE Applications	162
IE Tasks	164
The General Pipeline for IE	165
Keyphrase Extraction	166
Implementing KPE	167
Practical Advice	168
Named Entity Recognition	169
Building an NER System	171
NER Using an Existing Library	175
NER Using Active Learning	176
Practical Advice	177
Named Entity Disambiguation and Linking	178
NEL Using Azure API	179

Relationship Extraction	181
Approaches to RE	182
RE with the Watson API	184
Other Advanced IE Tasks	185
Temporal Information Extraction	186
Event Extraction	187
Template Filling	189
Case Study	190
Wrapping Up	193
6. Chatbots.....	199
Applications	200
A Simple FAQ Bot	201
A Taxonomy of Chatbots	202
Goal-Oriented Dialog	204
Chitchats	204
A Pipeline for Building Dialog Systems	205
Dialog Systems in Detail	206
PizzaStop Chatbot	208
Deep Dive into Components of a Dialog System	218
Dialog Act Classification	219
Identifying Slots	219
Response Generation	220
Dialog Examples with Code Walkthrough	221
Other Dialog Pipelines	226
End-to-End Approach	227
Deep Reinforcement Learning for Dialogue Generation	227
Human-in-the-Loop	228
Rasa NLU	229
A Case Study: Recipe Recommendations	232
Utilizing Existing Frameworks	233
Open-Ended Generative Chatbots	235
Wrapping Up	236
7. Topics in Brief.....	241
Search and Information Retrieval	243
Components of a Search Engine	245
A Typical Enterprise Search Pipeline	248
Setting Up a Search Engine: An Example	249
A Case Study: Book Store Search	251
Topic Modeling	252
Training a Topic Model: An Example	256

What's Next?	257
Text Summarization	258
Summarization Use Cases	258
Setting Up a Summarizer: An Example	259
Practical Advice	260
Recommender Systems for Textual Data	262
Creating a Book Recommender System: An Example	263
Practical Advice	264
Machine Translation	265
Using a Machine Translation API: An Example	266
Practical Advice	267
Question-Answering Systems	268
Developing a Custom Question-Answering System	270
Looking for Deeper Answers	270
Wrapping Up	271

Part III. Applied

8. Social Media.....	277
Applications	279
Unique Challenges	280
NLP for Social Data	286
Word Cloud	286
Tokenizer for SMTD	288
Trending Topics	288
Understanding Twitter Sentiment	290
Pre-Processing SMTD	292
Text Representation for SMTD	296
Customer Support on Social Channels	299
Memes and Fake News	301
Identifying Memes	301
Fake News	302
Wrapping Up	304
9. E-Commerce and Retail.....	309
E-Commerce Catalog	310
Review Analysis	310
Product Search	311
Product Recommendations	311
Search in E-Commerce	311
Building an E-Commerce Catalog	314

Attribute Extraction	314
Product Categorization and Taxonomy	319
Product Enrichment	323
Product Deduplication and Matching	325
Review Analysis	326
Sentiment Analysis	327
Aspect-Level Sentiment Analysis	329
Connecting Overall Ratings to Aspects	331
Understanding Aspects	332
Recommendations for E-Commerce	334
A Case Study: Substitutes and Complements	335
Wrapping Up	338
10. Healthcare, Finance, and Law.....	341
Healthcare	341
Health and Medical Records	343
Patient Prioritization and Billing	344
Pharmacovigilance	344
Clinical Decision Support Systems	344
Health Assistants	344
Electronic Health Records	346
Mental Healthcare Monitoring	355
Medical Information Extraction and Analysis	357
Finance and Law	360
NLP Applications in Finance	362
NLP and the Legal Landscape	365
Wrapping Up	368
<hr/>	
Part IV. Bringing It All Together	
11. The End-to-End NLP Process.....	373
Revisiting the NLP Pipeline: Deploying NLP Software	374
An Example Scenario	376
Building and Maintaining a Mature System	378
Finding Better Features	379
Iterating Existing Models	380
Code and Model Reproducibility	381
Troubleshooting and Interpretability	381
Monitoring	384
Minimizing Technical Debt	385
Automating Machine Learning	386

The Data Science Process	390
The KDD Process	390
Microsoft Team Data Science Process	392
Making AI Succeed at Your Organization	394
Team	394
Right Problem and Right Expectations	395
Data and Timing	396
A Good Process	397
Other Aspects	398
Peeking over the Horizon	400
Final Words	403
Index.....	409