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**OPTIMISED CONTENT-SOCIAL BASED FEATURES FOR
FAKE NEWS DETECTION IN SOCIAL MEDIA USING TEXT
CLUSTERING APPROACH**

ADNAN HUSSEIN ALI BIN YAHYA



**DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
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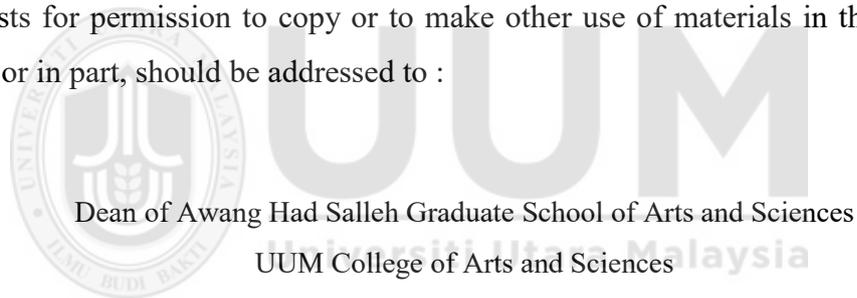
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Abstrak

Tugas mengesan berita palsu mempunyai kepentingan yang tinggi untuk mengurangkan penyebaran maklumat yang mengelirukan. Ketepatan model pengesanan berita palsu bergantung terutamanya pada kualiti ciri yang diekstrak yang dianalisis daripada berita dan kaedah yang digunakan dalam pengesanan. Ketepatan pengesanan model ini masih rendah kerana kekurangan penggunaan ciri yang berbeza dan batasan dalam kaedah yang digunakan. Untuk menangani masalah ini, penyelidikan ini membentangkan kaedah pengesanan berita palsu yang menggabungkan ciri yang berbeza dan kaedah pembangunan untuk fasa paling penting dalam proses pengesanan, termasuk pengekstrakan ciri, pemilihan ciri dan fasa pengesanan berita palsu. Tesis ini menangani proses pengekstrakan ciri berasaskan kandungan dan berasaskan sosial daripada berita dan menggabungkannya untuk menganalisis dan mengesan berita palsu dengan lebih baik. Selain itu, tesis ini menangani masalah pemilihan ciri melalui mereka bentuk kaedah pemilihan ciri pembalut novel berdasarkan Algoritma Pendebungaan Bunga Hibrid (HFPA). Secara khususnya, kajian ini mengacukan algoritma Pengoptimuman Particle Swarm (PSO) dengan FPA untuk mengatasi had masalah penerokaan FPA. Secara umumnya, proses pengesanan berita palsu dijalankan dalam dua fasa berbeza iaitu fasa pengesanan topik menggunakan kaedah pengelompokan tanpa pengawasan berasaskan graf berdasarkan HFPA dan Algoritma Pengelompokan Markov (MCL) yang dipanggil (HFPA-MCL) dan fasa pengesanan berita palsu menggunakan kaedah pengelompokan tanpa pengawasan berdasarkan algoritma K-means. Model pengesanan berita palsu yang dibangunkan diuji pada set data PHEME dengan menjalankan beberapa eksperimen terhadap kaedah garis dasar yang berbeza. Keputusan empirikal beberapa penambahbaikan membuktikan bahawa menggunakan HFPA-MCL pada gabungan ciri kandungan-sosial yang dioptimumkan mengatasi kaedah lain dari segi prestasi dan masa pengesanan dan pengurangan ciri. Akhirnya, penyelidikan ini menyimpulkan bahawa model pengesanan berita palsu yang dibangunkan berdasarkan ciri berasaskan kandungan-sosial yang direka boleh mengesan berita palsu dalam berita dunia sebenar dengan berkesan.

Kata Kunci: Pengesanan berita palsu, Pemilihan ciri, Algoritma pendebungaan bunga, Algoritma pengelompokan Markov, Pengelompokan tanpa pengawasan

Abstract

The task of detecting fake news is highly important to mitigate the misleading information spreading. The accuracy of fake news detection models relies mainly on the quality of the extracted features and the method used in detection. The detection accuracy of these models is still low due to the lack of utilizing different features and the limitations in the used methods. To address this problem, this research presents a fake news detection method that combines different features and developing methods for the most crucial phases in the detection process, including feature extraction, feature selection and fake news detection phases. This thesis tackles the extraction process of content-based and social-based features from the news and combines them for better analysis and detection of fake news. In addition, this thesis tackles the feature selection problem by designing a novel wrapper feature selection method based on the Hybrid Flower Pollination Algorithm (HFPA). In particular, this study hybridized the Particle Swarm Optimization algorithm (PSO) with FPA to overcome the limitation of the exploration problem of FPA. In general, the process of fake news detection was conducted in two different phases, the topic detection phase using a graph-based unsupervised clustering method based on HFPA and Markov Clustering Algorithm (MCL) called (HFPA-MCL) and the fake news detection phase using an unsupervised clustering method based on K-means algorithm. The developed fake news detection model is tested on the PHEME dataset by conducting several experiments against different baseline methods. The empirical results of several improvements prove that applying HFPA-MCL on the combination of the optimized content-social features outperforms other methods in terms of feature reduction and detection performance and time. Ultimately, this research concludes that the developed fake news detection model based on the designed content-social-based features can effectively detect fake news in real-world news.

Keywords: Fake news detection, Feature selection, Flower pollination algorithm, Markov clustering algorithm, Unsupervised clustering

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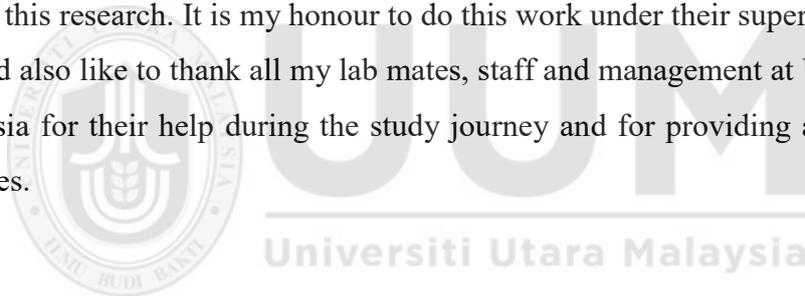


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List of Abbreviations

| | |
|--------|---|
| TF | Term Frequency |
| TF-IDF | Term Frequency - Inverse Document Frequency |
| POS | Part of Speech |
| LDA | Latent Dirichlet Allocation |
| NER | Name Entity Recognition |
| MHAs | Metaheuristics Algorithms |
| FPA | Flower Pollination Algorithm |
| BOW | Bag of Words |
| GA | Genetic Algorithm |
| PSO | Particle Swarm Optimization |
| CS | Cuckoo Search |
| MCS | Multilevel Coordinate Search |
| BA | Bat Algorithm |
| MCL | Markov Clustering Algorithm |
| BLC | Boolean Label Crowdsourcing |
| EANN | Event Adversarial Neural Network |
| SVM | Support Vector Machines |
| NB | Naive Bayes |
| DT | Decision Trees |
| NN | Neural Networks |
| RF | Random Forest |
| NLTK | Natural Language Toolkit |
| LIWC | Linguistic Inquiry and Word Count |
| PCFG | Probabilistic Context Free Grammar |
| MLP | Multilayer Perceptron |
| CHI | Chi-square |
| MI | Mutual Information |

| | |
|------|--|
| IG | Information Gain |
| BBBC | Big-Bang-Big-Crunch |
| ACO | Ant Colony Optimization |
| GWO | Grey Wolf Optimization |
| SSO | Social Spider Optimization |
| FA | Firefly Algorithm |
| AIS | Artificial Immune System |
| TS | Tabu Search |
| SA | Simulated Annealing |
| CNN | Convolutional Neural Networks |
| RNN | Recurrent Neural Network |
| NLP | Natural Language Processing |
| SGD | Stochastic Gradient Descent |
| SEIR | Susceptible Exposed Infected Removed |
| SCIR | Susceptible Contacted Infected Removed |
| SSE | Sum of Squared Errors |
| VSM | Vector Space Model |
| Q | Modularity Q |
| SSA | Salp Swarm Algorithm |
| JA | Jaya Algorithm |
| P | Precision |
| R | Recall |
| F | F-Score |
| TTR | Type Token Ration |
| PRP | Personal Pronoun |

CHAPTER ONE

INTRODUCTION

This chapter presents a background of the research, research problem, research questions, and research objectives. In addition, it discusses the study scope and the significance of the research. At the end, it concludes with an overview of the other remaining chapters.

1.1 Background

With the remarkable growth of technology and the Internet, human life has become more comfortable in various aspects such as health, education, construction, industry, and especially in the aspect of information gain and dissemination. The Internet revolution has significantly contributed to information diffusion at the lowest cost through various websites such as news websites and social networks like Twitter, Facebook, Instagram, Linked-in and others. In human life, many events happen daily, and people worldwide share and spread news about these events. The wide usage of social networks nowadays makes spreading and sharing different news very easy and almost costs nothing. These networks nearly replaced the traditional channels and agencies of news resources in disseminating news to users (Shu et al., 2017; Zhang & Ghorbani, 2019).

On the other hand, this revolution and the rapid spread of online information and the Internet caused some new problems, such as espionage, hackers, and the spread of fake news and false information among people. Fake news is one of the most active problems today (Pérez-Rosas et al., 2017; Schiff et al., 2023; Silva & Vaz, 2024;

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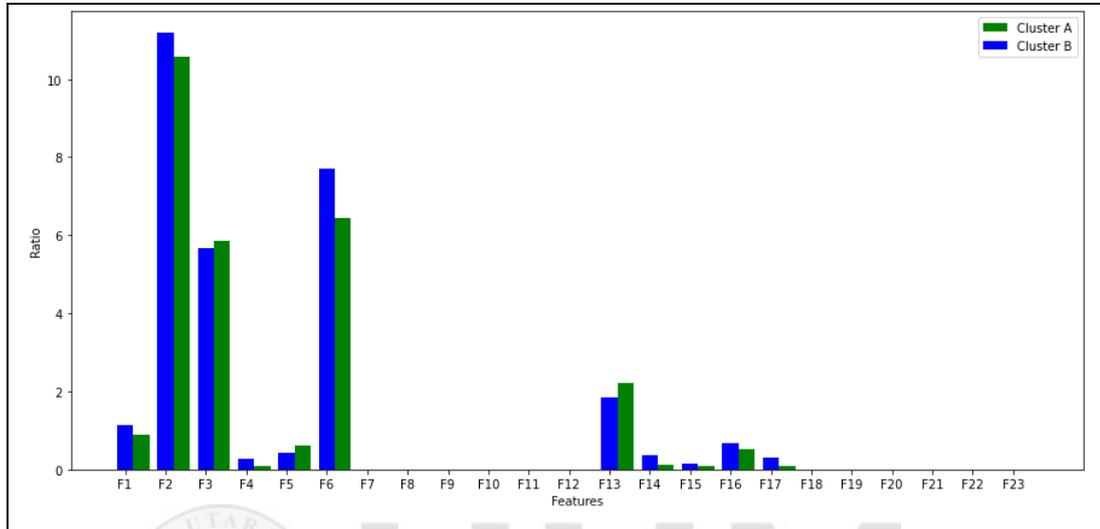
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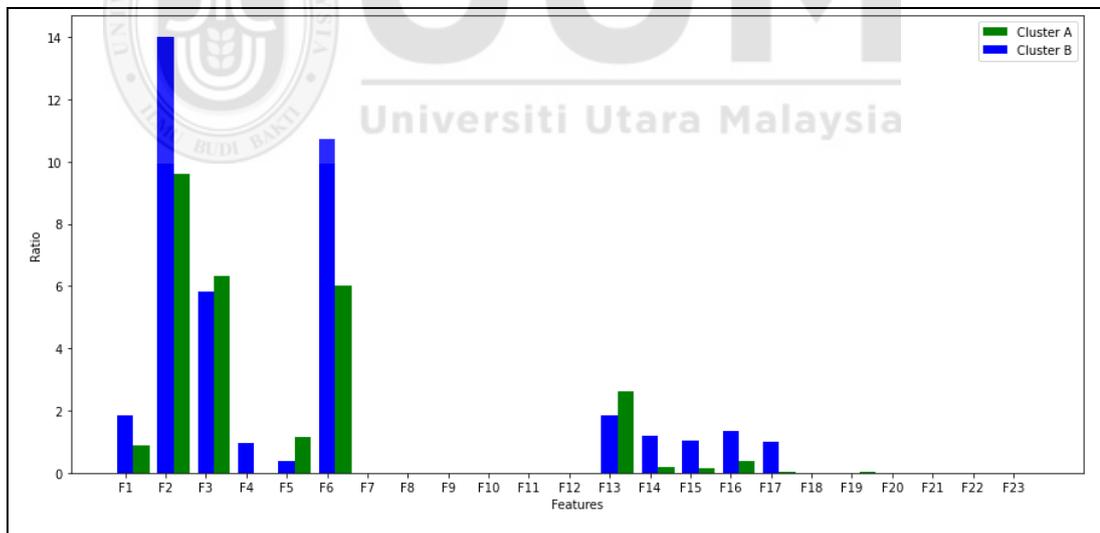
Appendix A

Features Analysis Charts for K-means Clusters

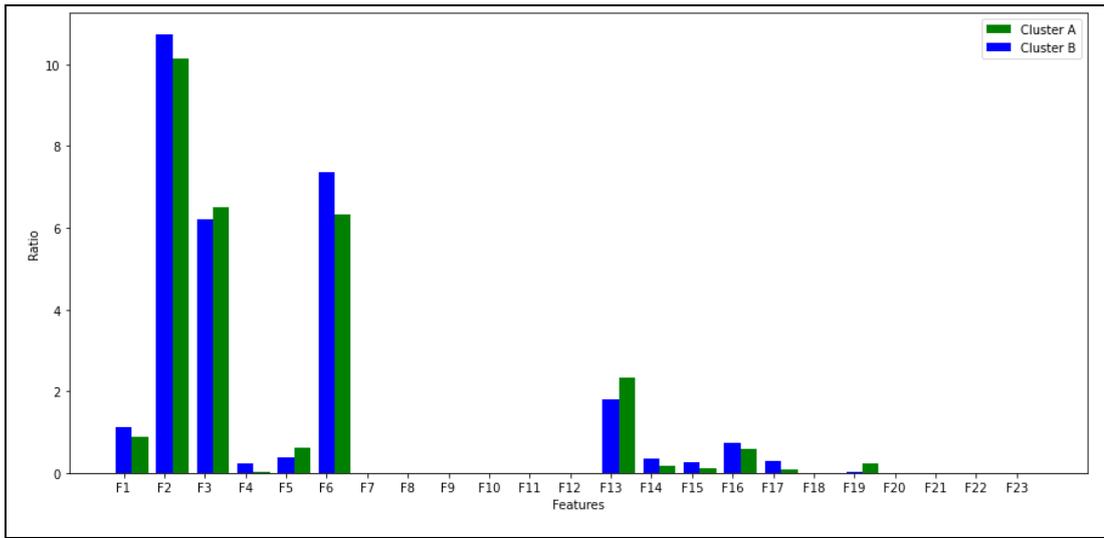
Linguistic Features



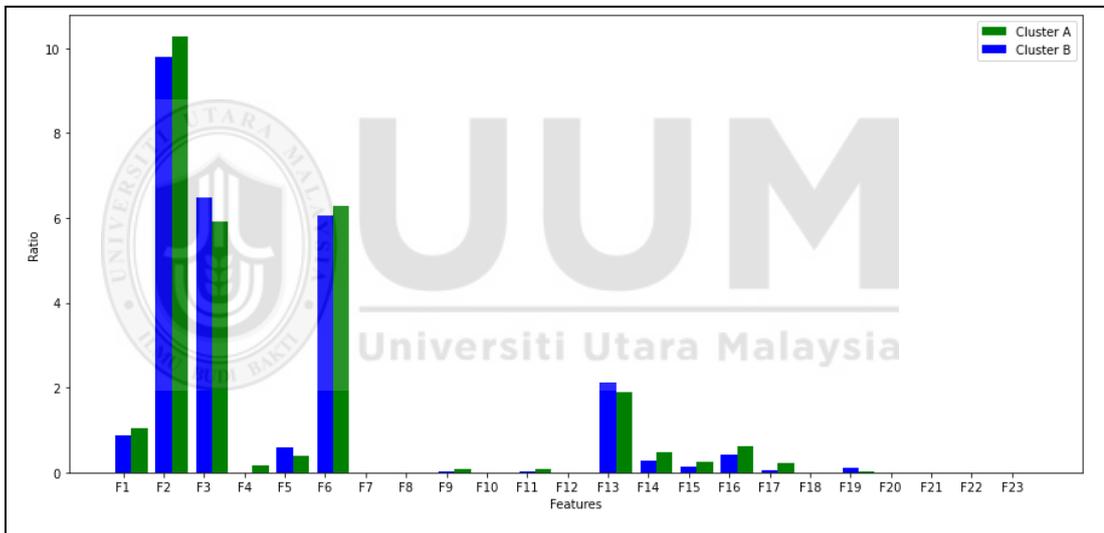
Linguistic features for Cluster 1-A and Cluster 1-B



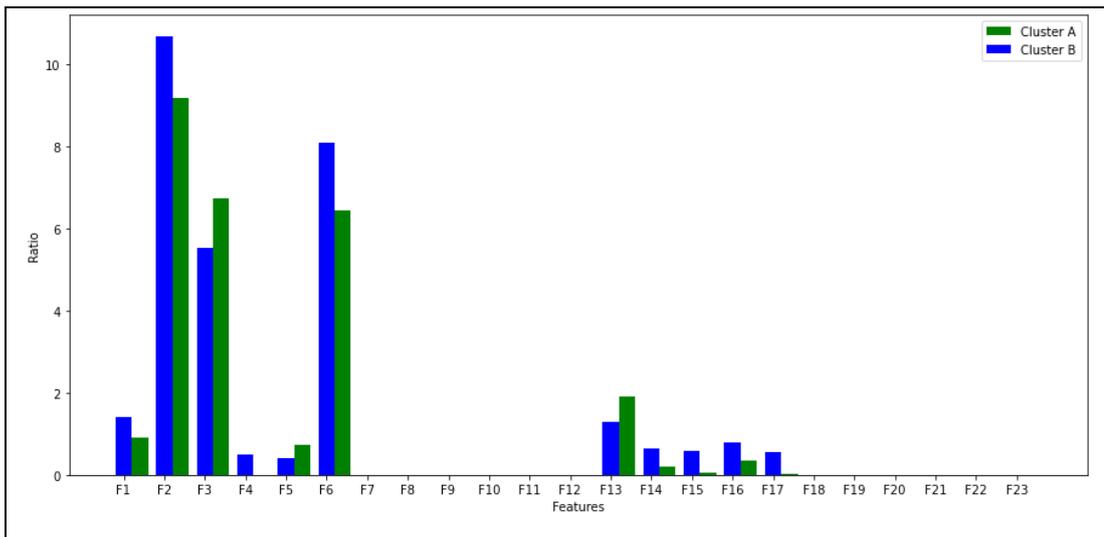
Linguistic features for Cluster 2-A and Cluster 2-B



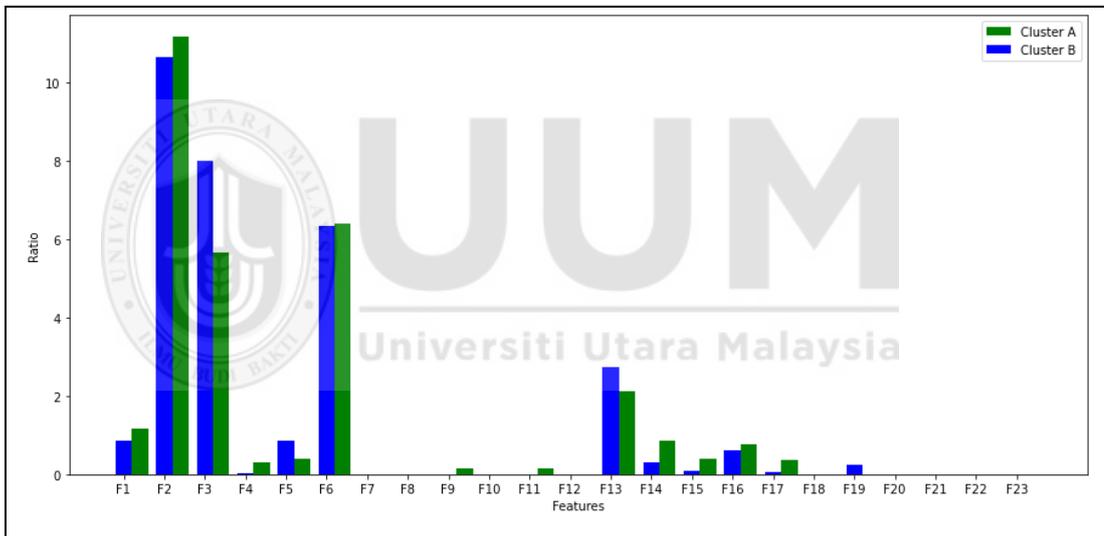
Linguistic features for Cluster 3-A and Cluster 3-B



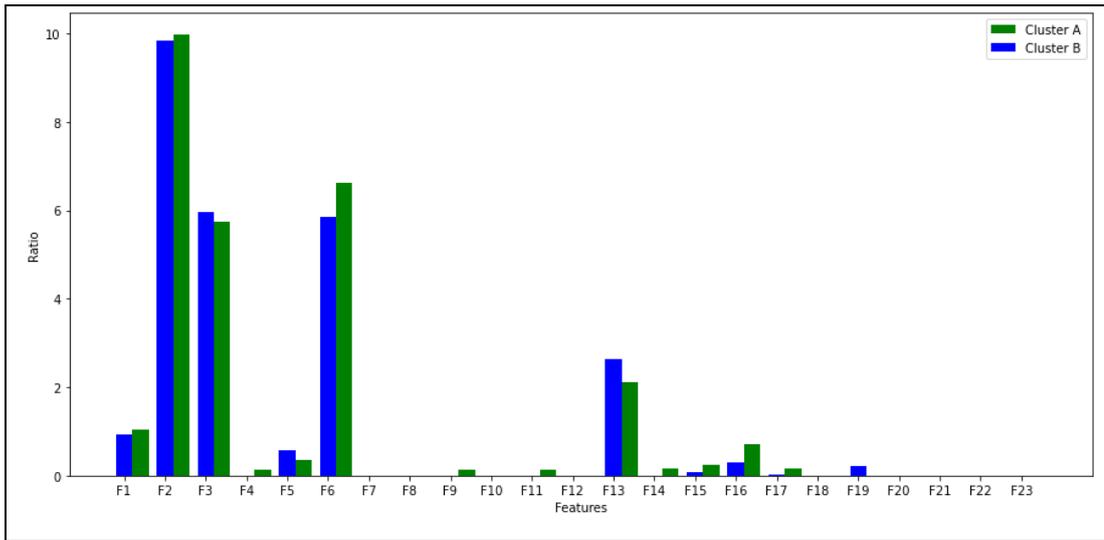
Linguistic features for Cluster 4-A and Cluster 4-B



Linguistic features for Cluster 5-A and Cluster 5-B

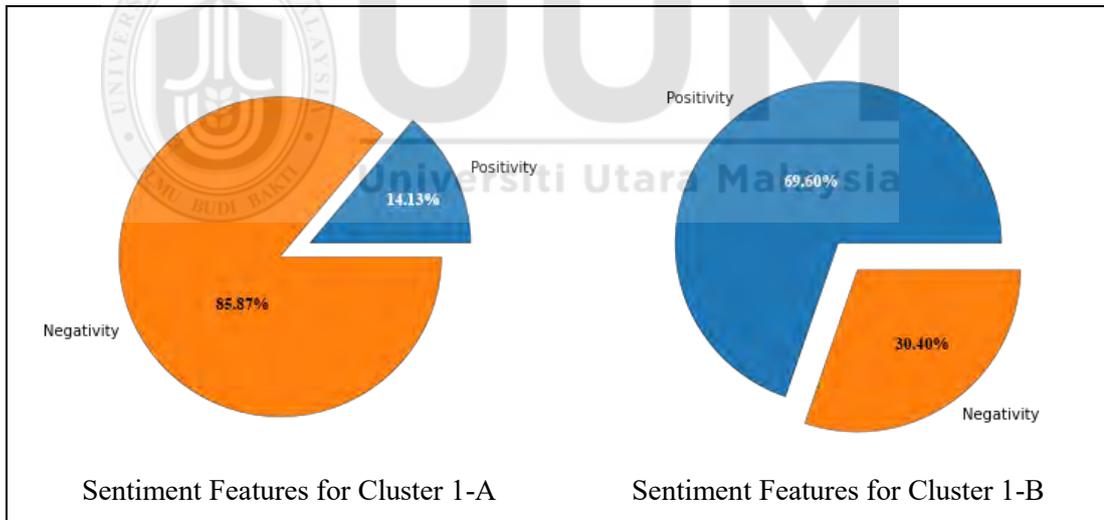


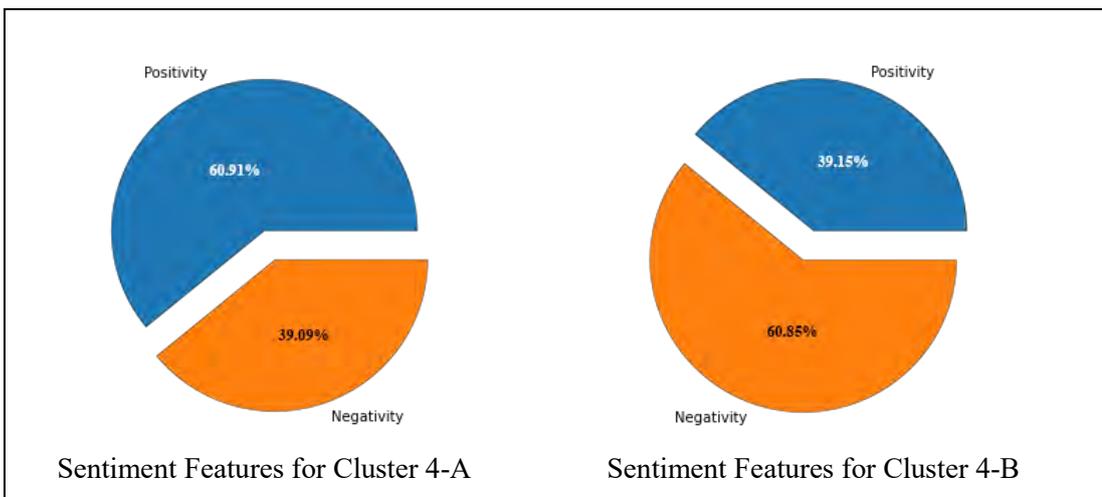
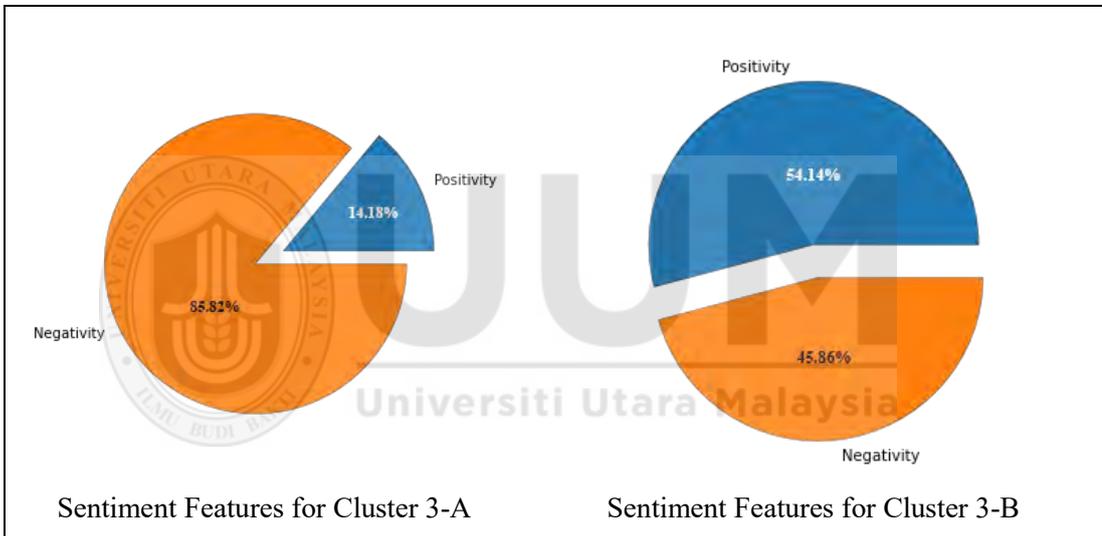
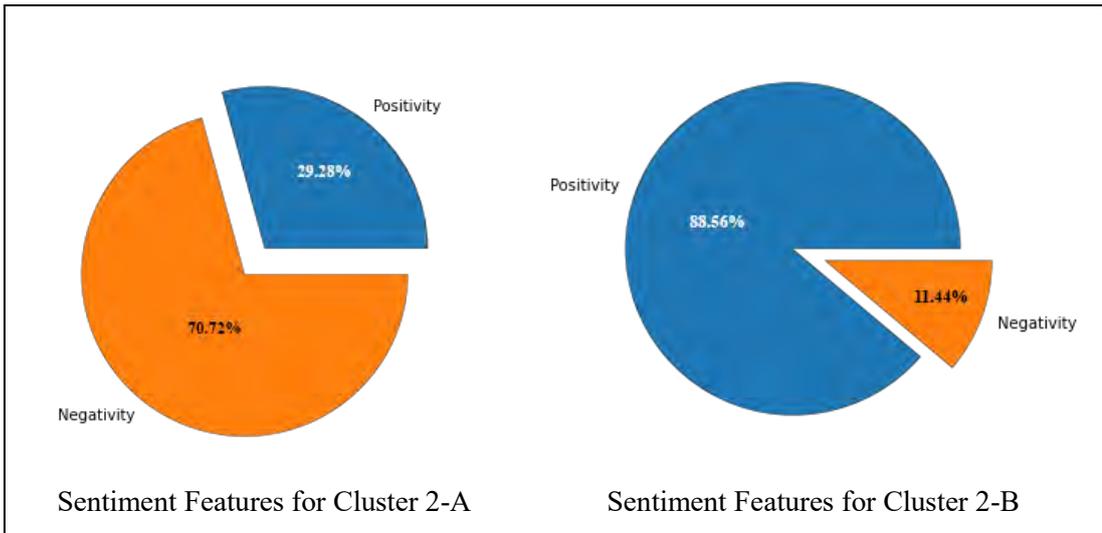
Linguistic features for Cluster 6-A and Cluster 6-B

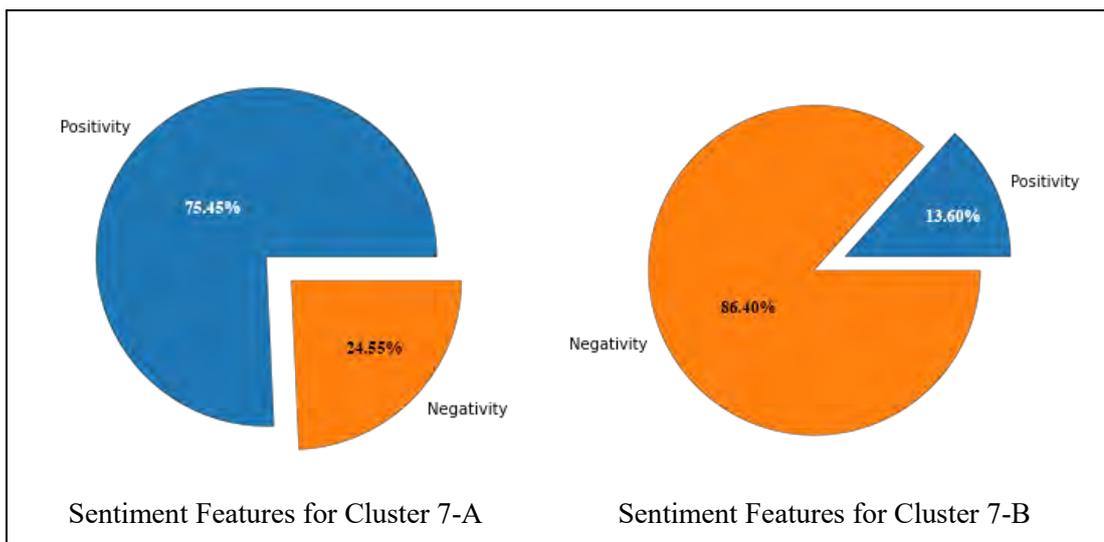
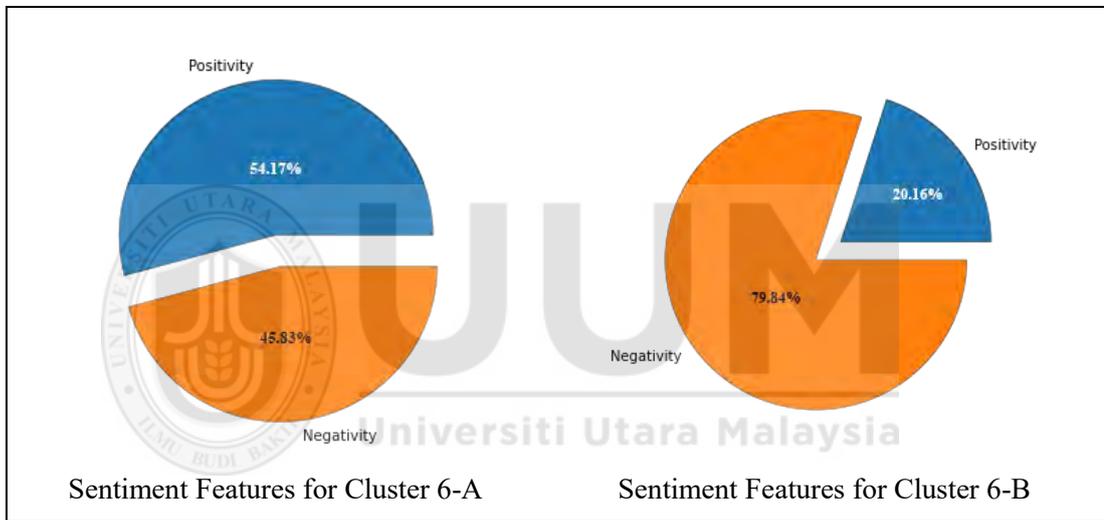
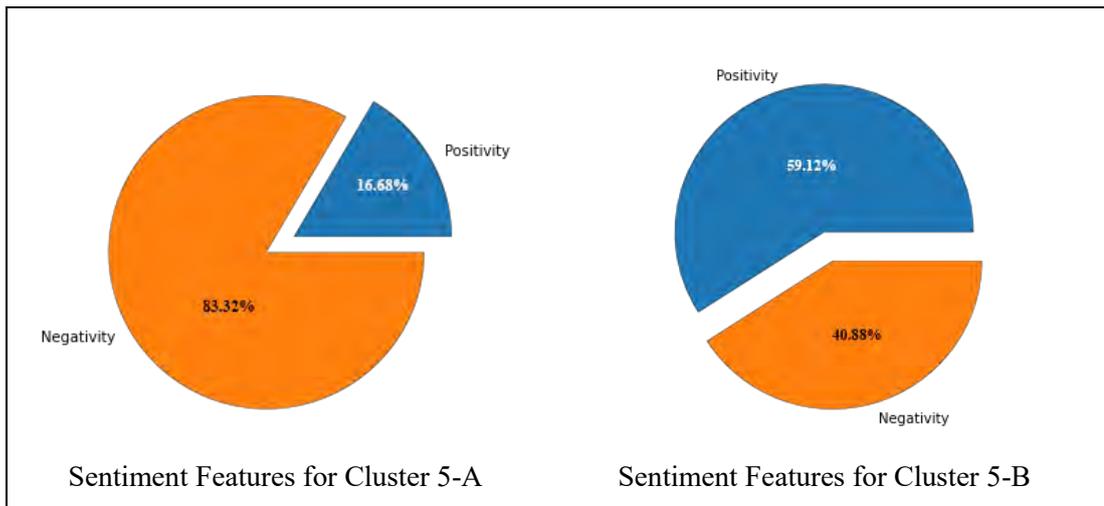


Linguistic features for Cluster 7-A and Cluster 7-B

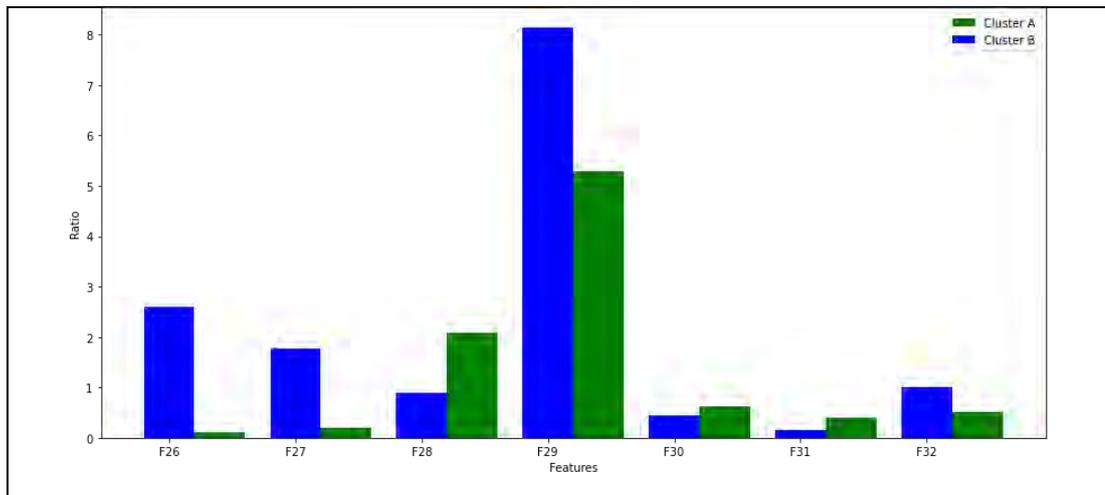
Sentiment Features



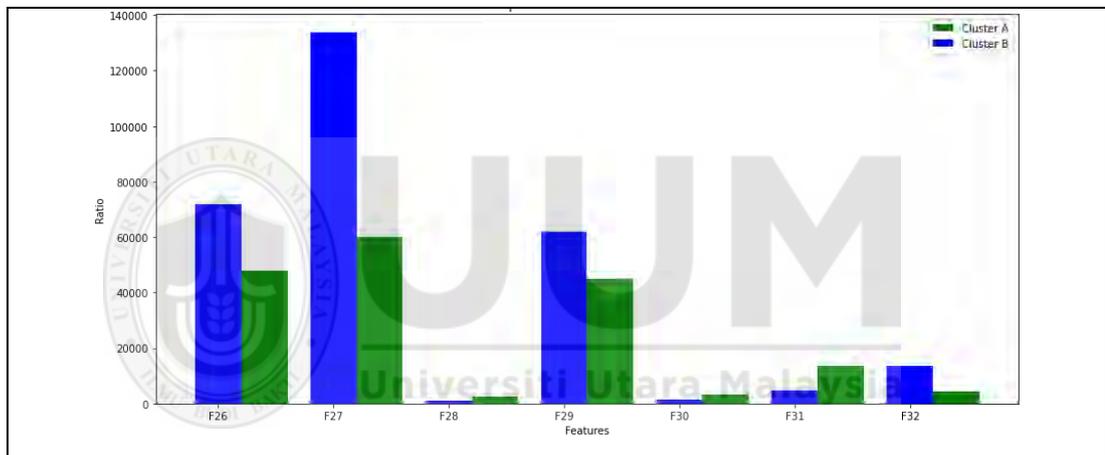




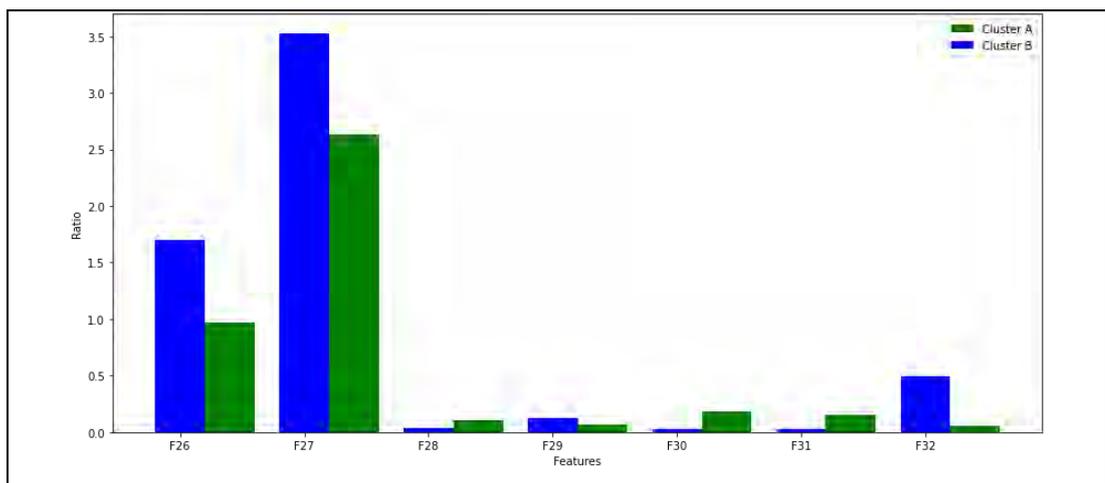
User-Based Features



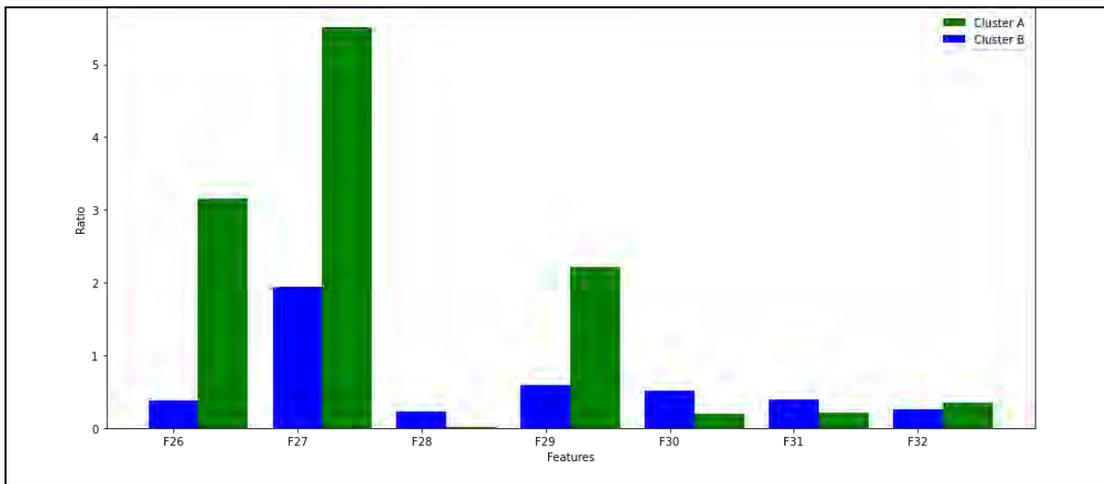
User Based features for Cluster 1-A and Cluster 1-B



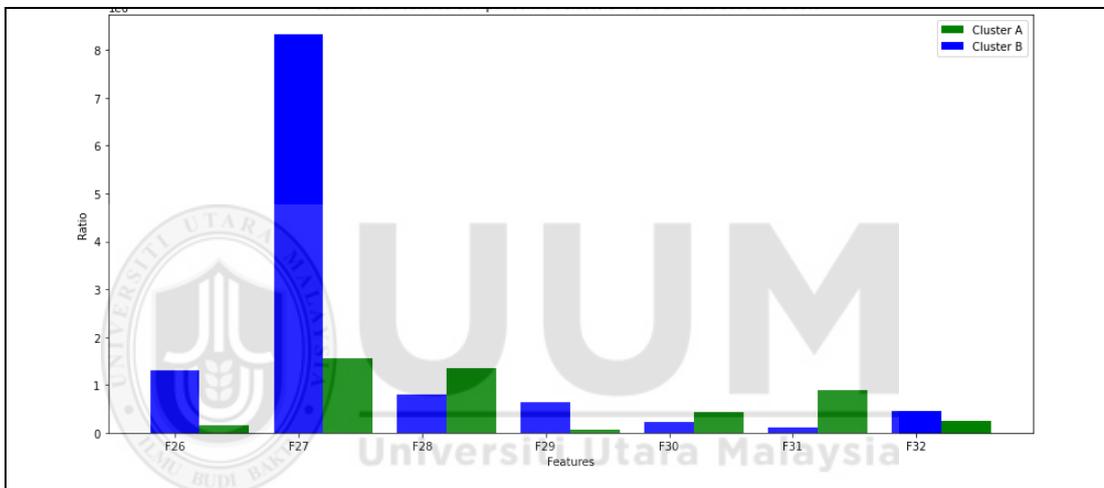
User Based features for Cluster 2-A and Cluster 2-B



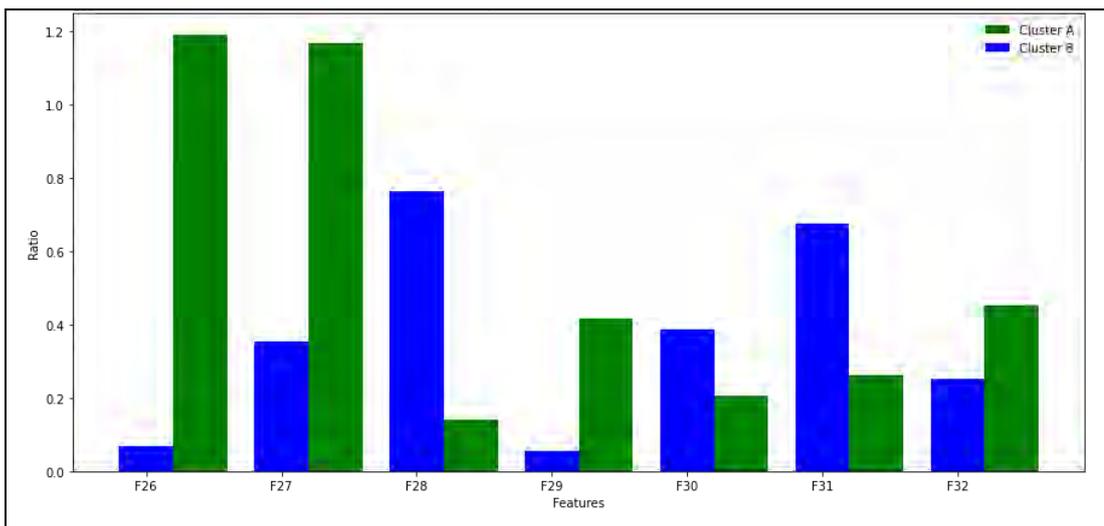
User Based features for Cluster 3-A and Cluster 3-B



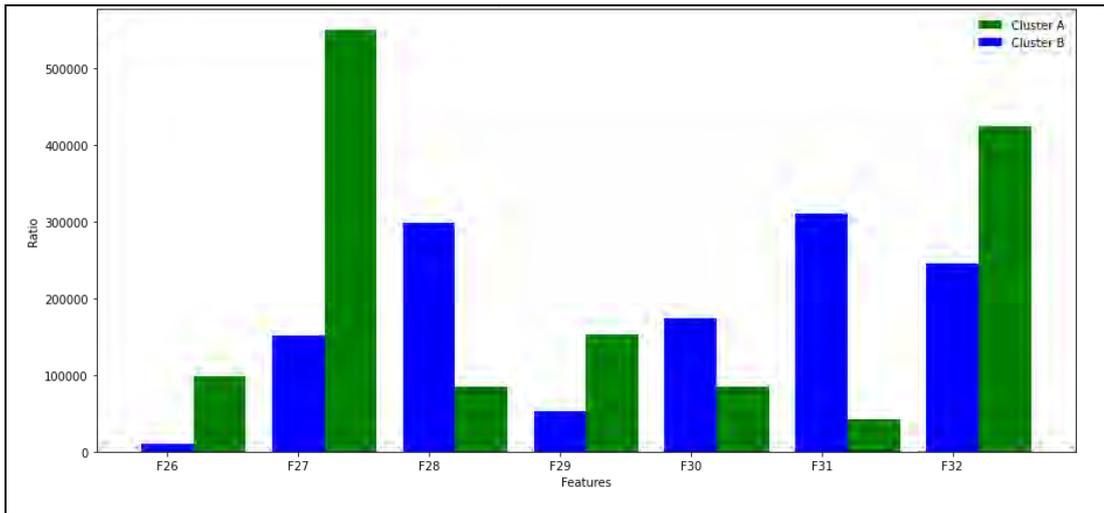
User Based features for Cluster 4A and Cluster 4-B



User Based features for Cluster 5-A and Cluster 5-B

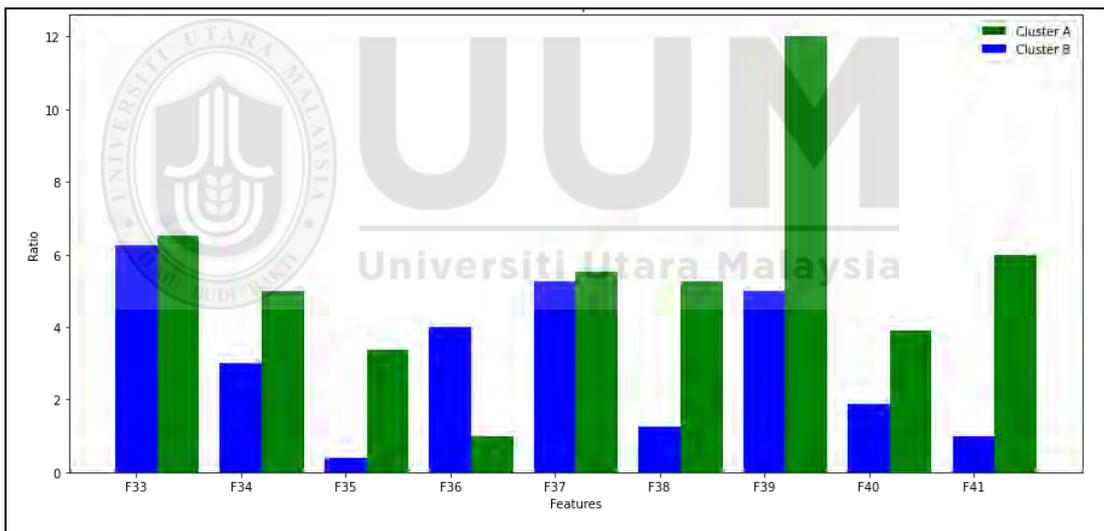


User Based features for Cluster 6A and Cluster 6-B

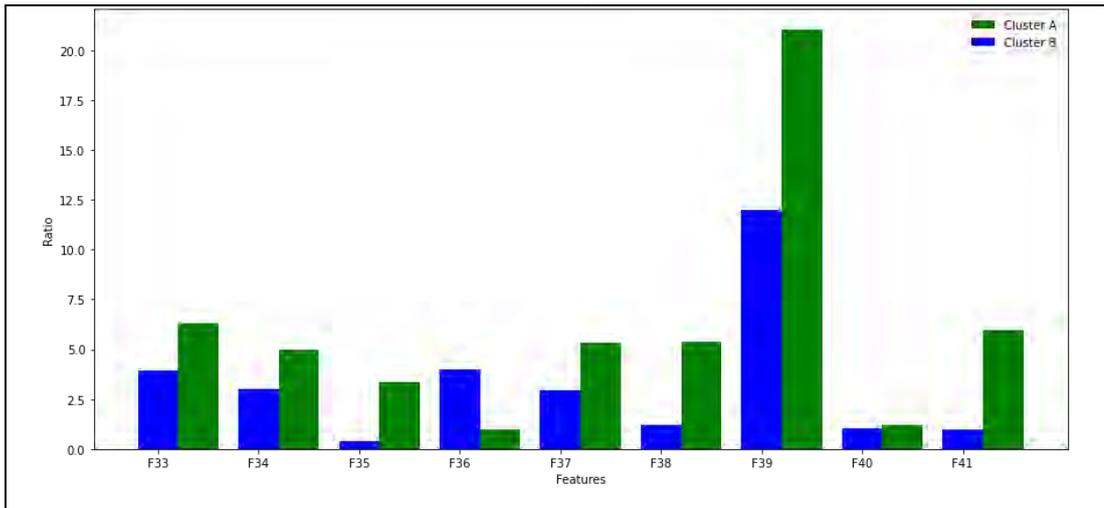


User Based features for Cluster 7-A and Cluster 7-B

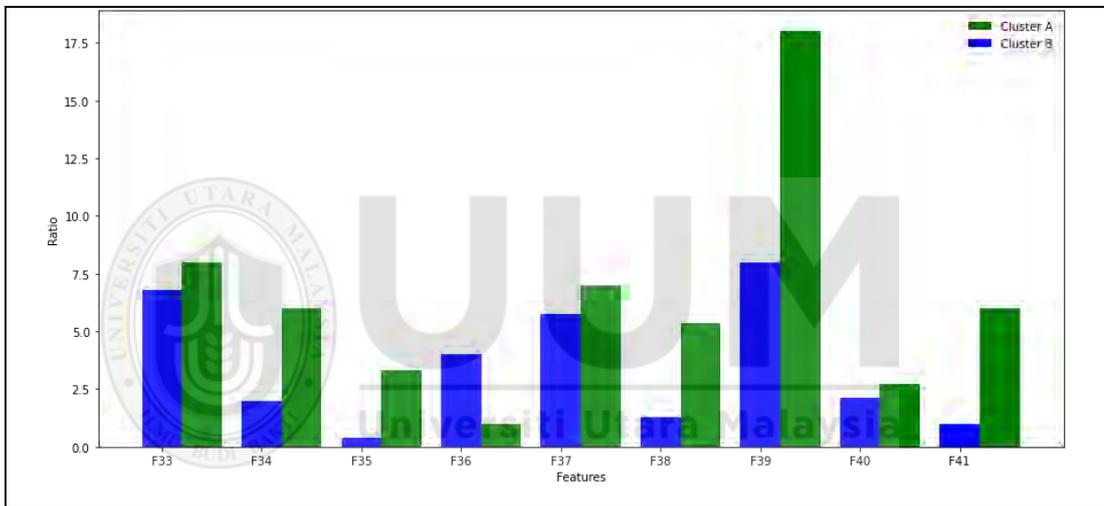
Network-Based Features



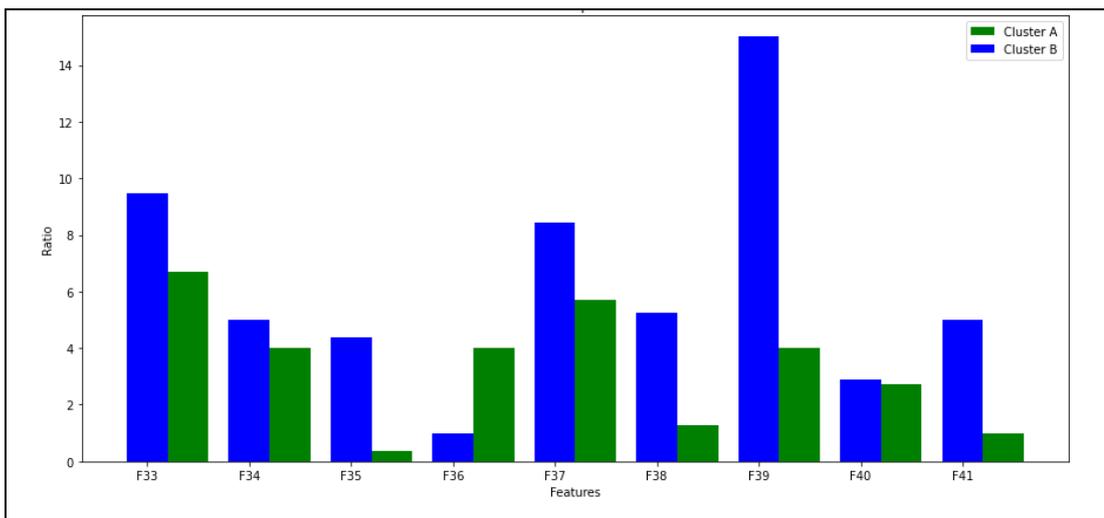
Network Based features for Cluster 1-A and Cluster 1-B



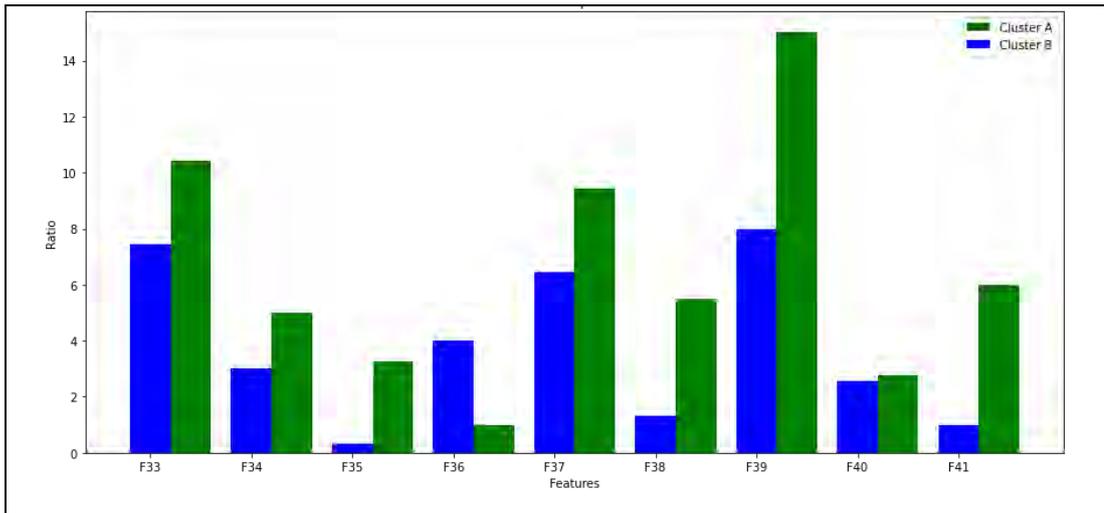
Network Based features for Cluster 2-A and Cluster 2-B



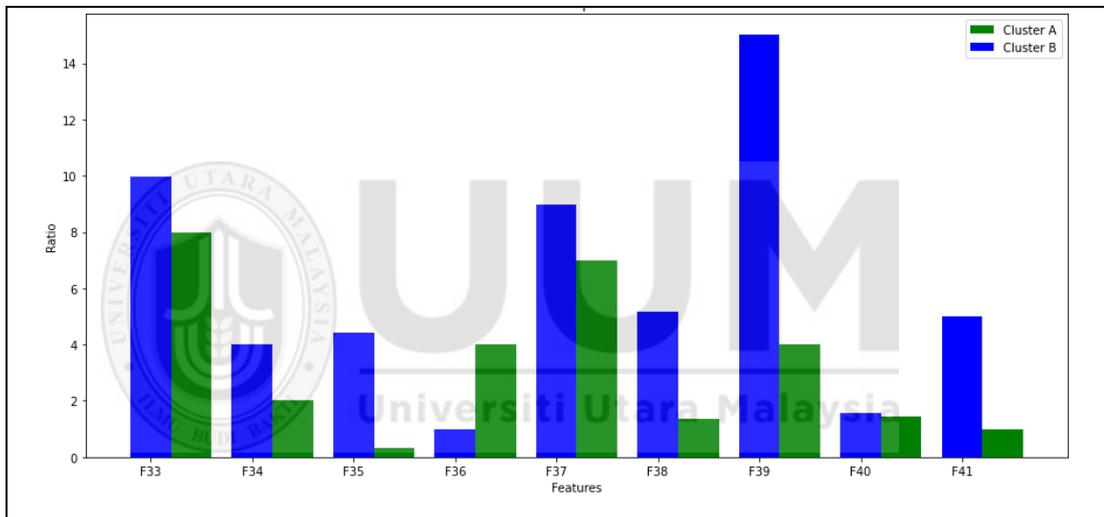
Network Based features for Cluster 3-A and Cluster 3-B



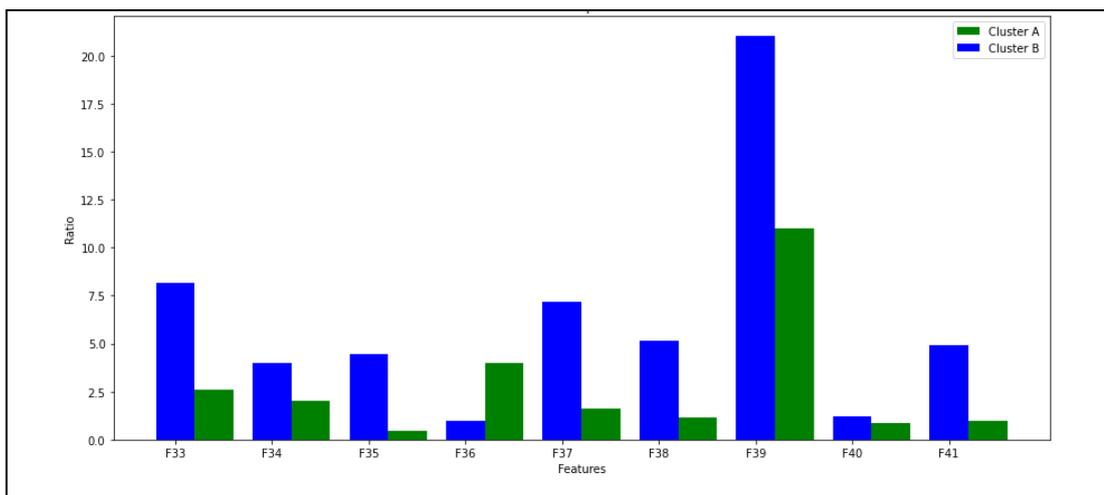
Network Based features for Cluster 4-A and Cluster 4-B



Network Based features for Cluster 5-A and Cluster 5-B

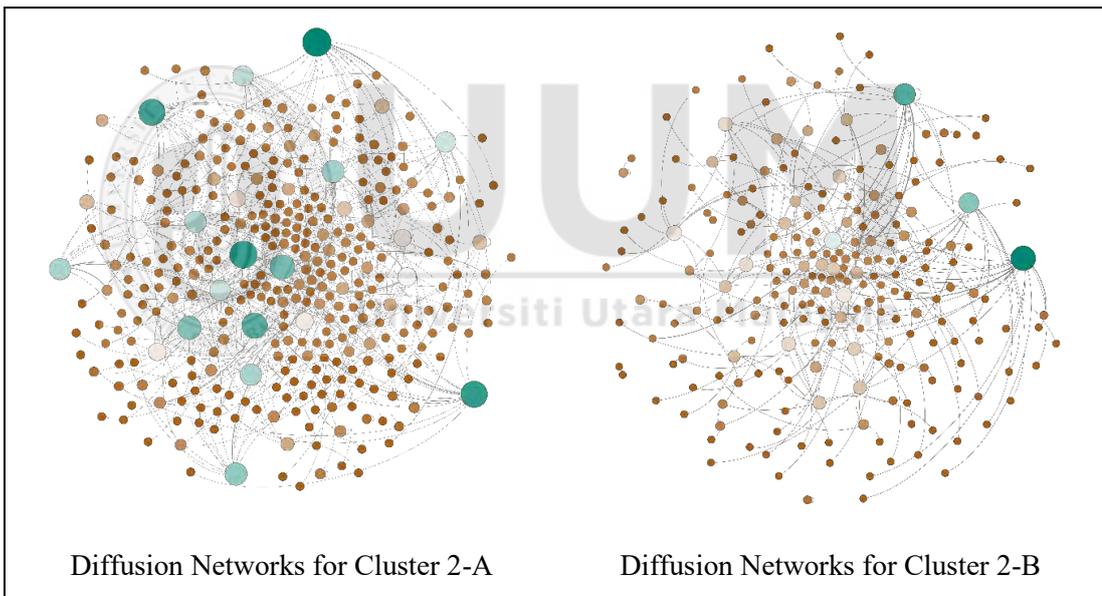
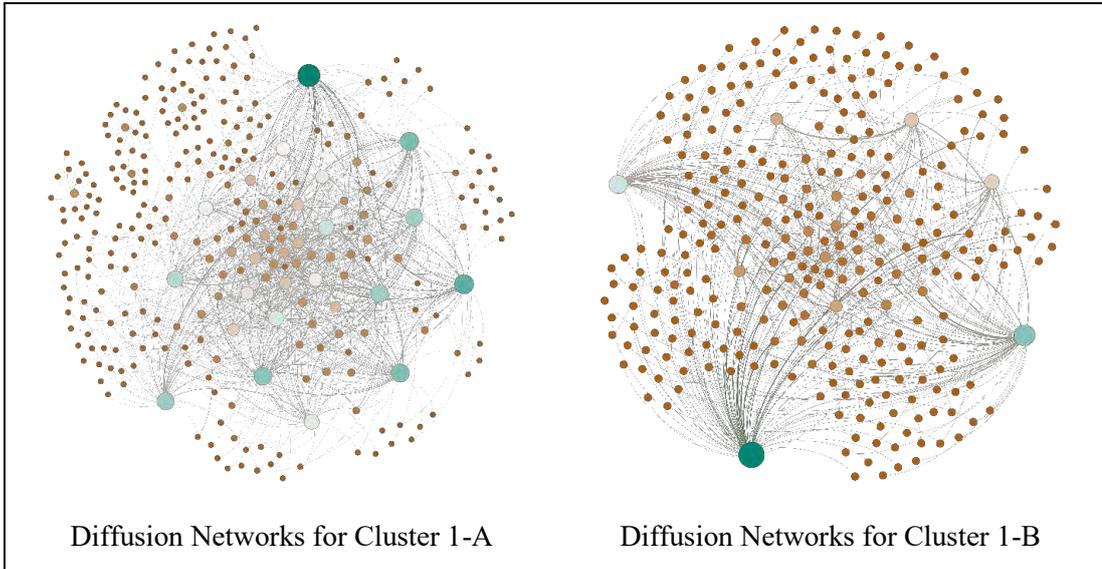


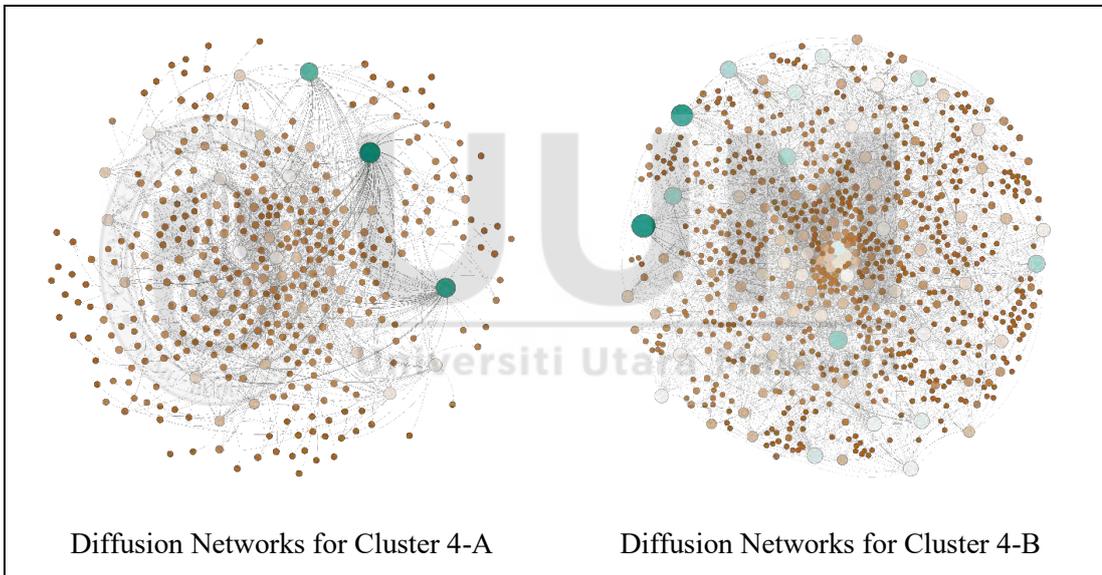
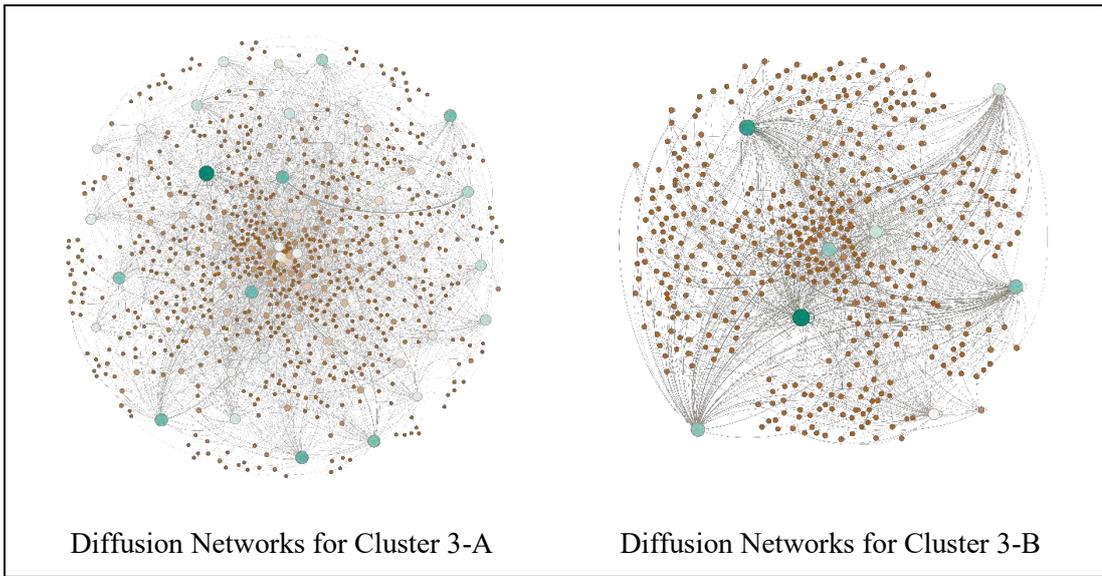
Network Based features for Cluster 6-A and Cluster 6-B

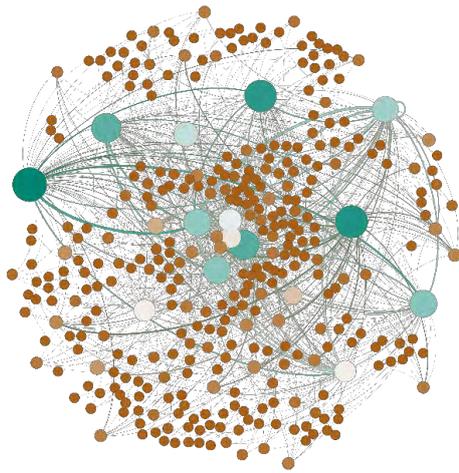


Network Based features for Cluster 7-A and Cluster 7-B

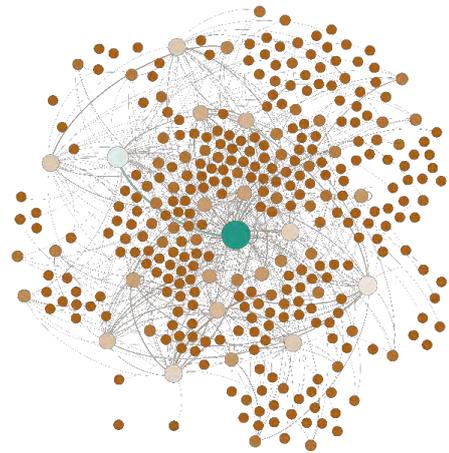
Diffusion Networks



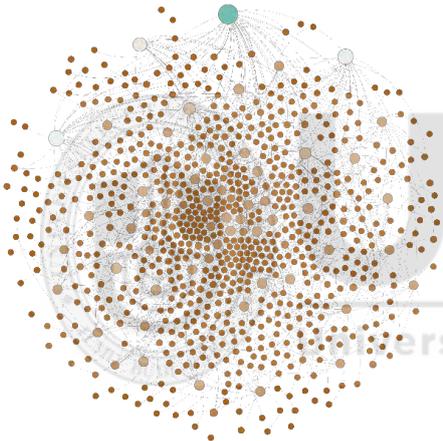




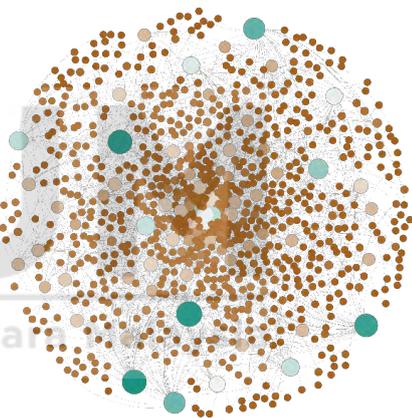
Diffusion Networks for Cluster 5-A



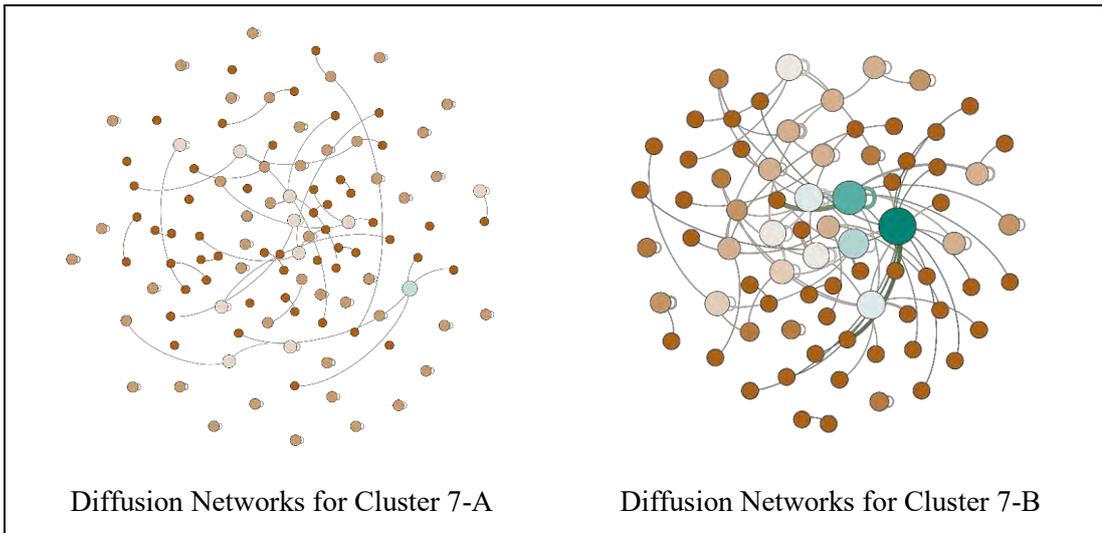
Diffusion Networks for Cluster 5-B



Diffusion Networks for Cluster 6-A



Diffusion Networks for Cluster 6-B



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Appendix B

LDA Analysis Results

1. LDA Analysis Results for Basic MCL Clusters

Cluster 1:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: haron moni identifi assault man murder hard believ god lindt | 3.05% |
| Topic 2: illridewithyou support updat sydney australian muslim hostage cafe amaz racism | 3.05% |
| Topic 3: prayer hostage sydney sieg sydney right say offic i injur think situat | 3.05% |
| Topic 4: sydney hostage cafe peopl sydney sieg held sieg islam live australian | 3.05% |
| Topic 5: hostage sydney sieg abbot lindt pray toni sydney heard cafe prime | 3.05% |
| Topic 6: imag sydney sieg situat need sydney everyon show ammunit media live | 3.05% |
| Topic 7: sydney sieg gun muslim illridewithyou solidar gunman thousand meet look transport | 37.06% |
| Topic 8: sydney sydney sieg hostage cafe peopl escap sieg polic lindt australia | 3.05% |
| Topic 9: selfi take terror sydney sieg peopl sieg sydney sick cafe outsid | 3.05% |
| Topic 10: sydney sieg sydney hostage cafe polic peopl break sieg news flag | 38.51% |

Cluster 2:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: much charliehebdo name eye innoc ever offens launch peopl christma | 2.54% |
| Topic 2: charliehebdo love hate attack stronger freedom terrorist muslim say pari | 2.54% |
| Topic 3: charliehebdo one serious suspect well cartoon talk publish report quit | 2.54% |
| Topic 4: charliehebdo speech victim free amp merabet attack ahm jesuischarli stand | 2.54% |
| Topic 5: charliehebdo pari attack charli hebdo polic hostage french kill shoot | 77.16% |
| Topic 6: victim charliehebdo kouachi amp prayer afp famili thought ahmadiyya attack | 2.54% |
| Topic 7: presid charliehebdo condemn attack last islam obama like tweet world | 2.54% |
| Topic 8: banksi jesuischarli solidar charliehebdo show user account twitter evet tribut | 2.54% |
| Topic 9: charliehebdo cartoon qaeda yorker new list editor yemen iamcharliehebdo solidar | 2.54% |
| Topic 10: pari hebdo charli polic charliehebdo hostage attack break dead shoot | 2.54% |

Cluster 3:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: ferguson look help prayer like polic tremend sound larg store | 2.50 % |
| Topic 2: protestor ferguson polic remind someon pleas outsid year shoot street | 2.50 % |
| Topic 3: ferguson chief polic robberi dog brought crowd mikebrown kill releas | 2.50 % |
| Topic 4: ferguson polic mikebrown brown robberi offic shot chief cop kill | 77.52 % |
| Topic 5: charg beat uniform man cop bleed ferguson properti protest blood | 2.50 % |
| Topic 6: happen ferguson youth young okay join tens anoth stl mikebrown | 2.50 % |

| | |
|---|--------|
| Topic 7: ferguson assassin offic polic mikebrown black charact suspect call teot | 2.50 % |
| Topic 8: ferguson polic mikebrown kill fergusonshoot leav follow shoot stori noth | 2.50 % |
| Topic 9: hand ferguson mikebrown loui shot counti think robberi shoot stop | 2.50 % |
| Topic 10: opfergunson face street traffic block let initi need ferguson so | 2.50 % |

Cluster 4:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: grey mourn logo chang white sign germanw plane crash start | 2.32 % |
| Topic 2: depress serious pilot episod newspaper wakeupamerica bild copilot suffer went | 2.32 % |
| Topic 3: ministri interior debri altitud french airbus germanw locat meter amp | 2.32 % |
| Topic 4: crash know plane germanw far holland survivor anchor cnn mountain | 2.32 % |
| Topic 5: emerg call crash distress germanw word aircraft kill imag pilot | 2.32 % |
| Topic 6: germanw crash plane french flight airbus alp break pilot franc | 79.09 % |
| Topic 7: flight feet radar ten plung minut accord famili data germanw | 2.32 % |
| Topic 8: germani spain germanw selfi twitter contact anti hostag abbott data | 2.32 % |
| Topic 9: fear dead crash franc germanw southern passeng confirm airbus lufthansa | 2.32 % |
| Topic 10: town germanw near break crash knock south got spree presid | 2.32 % |

Cluster 5:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: sydney sieg confirm australia love sydney polic everyon injur news dead | 3.01 % |
| Topic 2: releas communiti pleas sydney sieg opposit pray worker muslim small read | 3.01 % |
| Topic 3: know sydney sieg prayer friend thought affect famili one peopl hashtag | 3.01 % |
| Topic 4: media request sydney sieg social martinplac lindt scene individu peac share | 3.01 % |
| Topic 5: sydney sieg Sydney hostag cafe polic break sieg situat australian illridewithyou | 72.92 % |
| Topic 6: sydney hostag sydney sieg situat martin updat cafe place report say | 3.01 % |
| Topic 7: sydney sieg hostag break escap held two sydney number one call | 3.01 % |
| Topic 8: sydney sieg selfi still thing sleep best live illridewithyou take bed | 3.01 % |
| Topic 9: sydney hostag polic cafe held flag situat sieg break sydney sieg | 3.01 % |
| Topic 10: illridewithyou say support sydney sieg australian muslim fear run amid sydney | 3.01 % |

Cluster 6:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: shoot polic centr rideau ottawa confirm parliament hill break say | 3.93 % |
| Topic 2: know far ottawa ottawashoot edg moment violenc chao come silenc | 3.93 % |
| Topic 3: shoot ottawa parliament coverag watch call hill shooter prayer secur | 3.93 % |
| Topic 4: ottawa shoot parliament shot solider ottawashoot polic hill memori war | 64.66 % |
| Topic 5: shot soldier parliament memori war cirillo nathan ottawa kill ottawashoot | 3.93 % |
| Topic 6: michael bibeau zehaf suspect gunman born ottawa develop isi soldier | 3.93 % |
| Topic 7: minist stephen harper parliament norad hero prime alert left say | 3.93 % |
| Topic 8: game leaf postpon nhl ottawa tonight senat scene hill mapl | 3.93 % |
| Topic 9: ast reb pts hometown appear drop ottawa verdict downtown thought | 3.93 % |
| Topic 10: ottawa thought stay safe polic everyon today shoot photo prayer | 3.93 % |

Cluster 7:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: sydney sieg sydney continu urg updat busi normal polic resid peac | 2.44 % |
| Topic 2: faith restor human sydney sieg polit say motiv sydney pray thing | 2.44 % |
| Topic 3: one martinplac opportunist add douchebag sydney sieg odd hate bigot already | 2.44 % |
| Topic 4: thought lay sydney sieg muslim prayer tonightcountless uncertain night home head | 2.44 % |
| Topic 5: sydney sieg hostag latest moment total escap sydney number left five | 2.44 % |
| Topic 6: hostag sydney sydney sieg cafe break gunman held report polic take | 2.44 % |
| Topic 7: sydney sydney sieg hostag cafe polic break sieg report peopl flag | 78.01 % |
| Topic 8: illridewithyou hashtag sydney shot australian sydney sieg solidar sieg cafe hostag | 2.44 % |
| Topic 9: hostag isi situat sydney flag storm taker cafe sydney sieg show | 2.44 % |
| Topic 10: martin place near polic sydney sieg sydney insid peopl australia flag | 2.44 % |

Cluster 8:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: putindead putin coup win west twitter check russia back event | 2.76 % |
| Topic 2: putin russia putindead due via born swiss coup plot next | 2.76 % |
| Topic 3: world funni say male exchang person may putindead caus patern | 2.76 % |
| Topic 4: putin coup forc sudden putinpregn american go realli slave putinmiss | 2.76 % |
| Topic 5: putindead putin amp hybrid updat told kremlin fallen girl last | 2.76 % |
| Topic 6: putin coup disappear palac find fend polit know pictur absenc | 2.76 % |
| Topic 7: Putin putindead coup russia kremlin moscow vladimir putinmiss disappear via | 75.14 % |
| Topic 8: moscow putin absenc coup indic putindead palac russia found putinmiss | 2.76 % |
| Topic 9: could vladimir disappear putin undergo mean specul putinumer putindead switzerland | 2.76 % |
| Topic 10: putin wait rumour coup russia russian imag today cdnpoli sourc | 2.76 % |

Cluster 9:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: brilliant negoti creativ express charliehebdo say jesuischarli non happen via | 2.93 % |
| Topic 2: islam charliehebdo say attack pictur report pari wait rais sum | 2.93 % |
| Topic 3: pari kosher supermarket hostag mond eastern situat shoot terrorist week | 2.93 % |
| Topic 4: defend right voltair freedom collect death artsbeat europ say suspect | 2.93 % |
| Topic 5: wish sympathi charli hebdo solidar tignous cabu charliehebdo dead charb | 2.93 % |
| Topic 6: coexist either go insist interior french gunmen last lose secur | 2.93 % |
| Topic 7: attack banksi charliehebdo strike peugeot magazin parissshoot bigot target northeast | 2.93 % |
| Topic 8: confirm charliehebdo peopl attack get gunmen take polic everi centr | 2.93 % |
| Topic 9: charliehebdo report pari afp arm kill shoot shout updat gunmen | 2.93 % |
| Topic 10: charliehebdo attack pari charli hebdo hostag report suspect polic gurlitt | 73.67 % |

Cluster 10:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: dispers ferguson germanw live crash say zone shot utc like | 4.53 % |
| Topic 2: convert report tell jet dusseldorf famili wors islam incid polic | 4.53 % |
| Topic 3: germanw ferguson crash polic pilot report convert muslim break news | 59.24 % |
| Topic 4: map cop polic share michael day emerg plot ceo boom | 4.53 % |
| Topic 5: barcelona posit stori someth file anti flightradar last bcn reason | 4.53 % |
| Topic 6: guy minist may six mouth everi transport messag twitter singl | 4.53 % |
| Topic 7: peopl breath end ferguson hour net offer rampag true head | 4.53 % |
| Topic 8: suburb offer convert prove america shoot loui mob becom across | 4.53 % |
| Topic 9: yemen ppl serious hashtag mani teenag unarmd airlin saga august | 4.53 % |
| Topic 10: germanw forc air wreckag conflict fergusonshoot broke wit christ thought | 4.53 % |

Cluster 11:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: given cornelius tune trove hundr receiv era magazin work swi | 2.91 % |
| Topic 2: regard heir say nazi part applic research german retract rip | 2.91 % |
| Topic 3: art accept fulli collect monday bequest gurlitt polic newspaper news | 2.91 % |
| Topic 4: gurlitt art museum accept collect swiss bem nazi kunstmuseum trove | 73.83 % |
| Topic 5: joel cousin leav art museum bequest artsbeat great return gurlitt | 2.91 % |
| Topic 6: decid possibl cornelius jock eve press direct affect mani charliehebdo | 2.91 % |
| Topic 7: break bern forc limbo analyst task make everyon prosecutor belong | 2.91 % |
| Topic 8: relat accord sign plot collect like goal piec earlier spitzweg | 2.91 % |
| Topic 9: art museum read twist nazi appal bern gurlitt thicken bequeath | 2.91 % |
| Topic 10: resolut court fit new weird museum conundrum prosecutor mani famili | 2.91 % |

2. LDA Analysis Results for FPA-MCL Clusters**Cluster 1:**

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: ottawa shoot parliament shot soldier polic ottawashoot hill memori break | 77.34 % |
| Topic 2: germanw crash info board news plane arriv airport dusseldorf onboard | 2.52 % |
| Topic 3: lufthansa fear hope spohr ottawashoot find survivor day ceo dark | 2.52 % |
| Topic 4: game postpon leaf nhl tonight ottawa senat ottawashoot know left | 2.52 % |
| Topic 5: ottawashoot room barricad stay parliament chair caucus safe black photo | 2.52 % |
| Topic 6: rout share map ottawa oklahomabehead shoot cover forthoodshoot crash terrorsim | 2.52 % |
| Topic 7: kevin vicker take hero sydney Sieg arm gunman sergeant start back | 2.52 % |
| Topic 8: famili thought today ottawa prayer pray everyon amp sincer colleagu | 2.52 % |
| Topic 9: ottawa away peopl window polic centr stay downtown shoot rideau | 2.52 % |
| Topic 10: flight emerg registr feet utc aipx lost airbus final cockpit | 2.52 % |

Cluster 2:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: polic shoot pari updat charliehebdo live break situat kill close | 2.7% |
| Topic 2: caucus ottawashoot room shoot barricad harper canadastrong stephen cdnpoli ottawastong | 2.7% |
| Topic 3: putin putindead coup russia kremlin moscow vladimir charliehebdo putinmiss dead | 75.32% |
| Topic 4: charliehebdo attack putin putindead dead ottawa pari russia coup confirm | 2.7% |
| Topic 5: putin shot dead target magazin attack putindead parissshoot rumor identifi | 2.7% |
| Topic 6: putin putindead via eyewit kremlin birth qaeda russia attack yemen | 2.7% |
| Topic 7: putin report putindead russia coup gunmen moscow charliehebdo pari kremlin | 2.7% |
| Topic 8: negoti hostag rideau publish dead sieg non freedom cartoon taker | 2.7% |
| Topic 9: coup putin attack nation disappear pictur sum islam vladimir alert | 2.7% |
| Topic 10: kill islam long polic say ottawa report charliehebdo terrorist war | 2.7% |

Cluster 3:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: charliehebdo attack muslim hostag pari islam shoot polic dead flag | 2.51% |
| Topic 2: charg assault charliehebdo satir french sexual tignous report get attack | 2.51% |
| Topic 3: charliehebdo stand akbar allahu shout video life take may shoot | 2.51% |
| Topic 4: chief editor toni abbott yorker new unclear charliehebdo polit motiv | 2.51% |
| Topic 5: said sydney sieg illridewithyou amaz kouachi actual site amp selfi suspect | 2.51% |
| Topic 6: charliehebdo pari attack hostag charli polic hebdo french report shoot | 50.74% |
| Topic 7: charliehebdo attack thought gunmen sydney sieg germanw peopl famili charli hebdo | 2.51% |
| Topic 8: woman australia freedom point last religion track televis terror tweet | 2.51% |
| Topic 9: charliehebdo ferguson report sydney sieg banksi cartoon attack jesuischarli sydney illridewithyou | 2.51% |
| Topic 10: exclus zone tomorrow work everyth pleas taken charliehebdo report presid | 2.51% |

Cluster 4:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: sydney sieg human america hypocrisi bundyranch restor imag wednesday faith break | 3.05% |
| Topic 2: sydney sieg sydney hostag cafe polic break sieg report peopl gunman | 72.52% |
| Topic 3: illridewithyou sydney sydney sieg safe stay muslim love everyon pleas hashtag | 3.05% |
| Topic 4: hostag cafe sydney sieg sydney lindt peopl report live news updat | 3.05% |
| Topic 5: game blame tonight cafe muslim opinion sydney sieg nhl son heard | 3.05% |
| Topic 6: ottawa thought prayer war memori parliament sydney sieg shoot amp sydney | 3.05% |
| Topic 7: polic ferguson confirm sydney sieg man shot break shoot gunman haron | 3.05% |
| Topic 8: head rip victim nathan cirillo cpl flag sydney face night | 3.05% |
| Topic 9: sydney arm cafe polic hostag storm sydney sieg live gunman heavili | 3.05% |
| Topic 10: uber price surg ride problem sydney came free sieg critic | 3.05% |

Cluster 5:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: germanw crash plane french break airbus flight alp pilot franc | 77.98% |
| Topic 2: australia polic sydney sydney sieg paramed run storm cafe delic scene | 2.45% |
| Topic 3: area ferguson ministri say crash germanw interior street polic debri | 2.45% |
| Topic 4: crash germanw live updat alp flight french crew airbus feet | 2.45% |
| Topic 5: sydney hostag flag held polic cafe situat unfold shop forc | 2.45% |
| Topic 6: crowd emerg last anxious disbelief place look mass ferguson martin | 2.45% |
| Topic 7: crash germanw break thought plane sydney peopl franc say news | 2.45% |
| Topic 8: happen horrif privileg comfort bed sleep realis thing muslim sydney sieg | 2.45% |
| Topic 9: polic ferguson brown germanw airbus depress shot near alp dign | 2.45% |
| Topic 10: sydney hostag five appear cafe continu sieg escap illridewithyou suspect | 2.45% |

Cluster 6:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: ferguson right peopl polic muslim murder sydney sieg dept sydney year | 4.61% |
| Topic 2: sydney sydney sieg cafe hostag australian sieg lindt isi ralli final | 4.61% |
| Topic 3: ferguson could polic amp gun hand wit carri much avert | 4.61% |
| Topic 4: ferguson polic mikebrown brown robberi shot kill shoot offic chief | 58.52% |
| Topic 5: sydney sieg gurlitt museum art help swiss american respond ferguson depress | 4.61% |
| Topic 6: ferguson report victim mike brown held local polic captiv approxim | 4.61% |
| Topic 7: work relat home suffer myth dispel initi love hard muslim | 4.61% |
| Topic 8: ferguson polic sydney get black unarm follow teenag charg uniform | 4.61% |
| Topic 9: sydney sieg sky muslim say ferguson pleas free news justic charliehebdo | 4.61% |
| Topic 10: still ferguson cop releas protestor neighborhood surveil robberi sung leav | 4.61% |

Cluster 7:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: cafe sydney sieg chocol australia say appear lindt facebook statement show | 2.96% |
| Topic 2: hostag break sydney escap two tuesday end sydney sieg situat herald | 2.96% |
| Topic 3: surreal museum latest islam bern cultur water massacr london book | 2.96% |
| Topic 4: hostag sydney sieg confirm involv text taker mother polic sieg cafe | 2.96% |
| Topic 5: friend thought prayer famili sydney sieg hostag unfold sever corn hidden | 2.96% |
| Topic 6: close bequest challeng museum collect gurlitt week bernbi artsbeat airspac | 2.96% |
| Topic 7: sydney hostag crisi cafe held seen australia fear moment backlash | 2.96% |
| Topic 8: gurlitt art museum swiss accept collect bem nazi trove kunstmuseum | 73.39% |
| Topic 9: cousin bern collect leav anoth toni cornelius attack communic speak | 2.96% |
| Topic 10: get heartstop moment cafe sydney sieg hostag bequest jewish bern art | 2.96% |

3. LDA Analysis Results for HFPA-MCL Clusters

Cluster 1:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: right say charliehebdo defend islam jesuischarli agre voltair user trend | 2.51% |
| Topic 2: one charliehebdo stand live kill time attempt rather free report | 2.51% |
| Topic 3: charliehebdo know far shoot pari long chase attack motorway shock | 2.51% |
| Topic 4: charliehebdo hebdo charli attack pari dead french polic shoot gunmen | 2.51% |
| Topic 5: charliehebdo muslim jesuischarli cartoon attack terrorist islam support terror condemn | 2.51% |
| Topic 6: banksi charliehebdo attack victim love jesuischarli muslim cartoonist stronger hate | 2.51% |
| Topic 7: interior prophet minist aveng charliehebdo shout say french detain murder | 2.51% |
| Topic 8: peopl religion charli mean die murder hebdo charliehebdo polic last | 2.51% |
| Topic 9: charliehebdo pari attack charli hebdo polic hostag french kill suspect | 77.44% |
| Topic 10: near pari eiffel charliehebdo tower offic trocadero attack live gunmen | 2.51% |

Cluster 2:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: right ferguson headquart polic dog floriss tri name dept shot | 4.68% |
| Topic 2: wilson darren break ferguson polic name town hand veteran shot | 4.68% |
| Topic 3: unarm kill ferguson mikebrown black cop old teen year right | 4.68% |
| Topic 4: ferguson polic mikebrown brown shot offic robberi cop chief kill | 57.88% |
| Topic 5: charg beat uniform man ferguson cop bleed prayer properti histori | 4.68% |
| Topic 6: crimin ferguson peac polic believ renishamcbrid mike black amp trayvonmartin | 4.68% |
| Topic 7: polic ferguson robberi chief mikebrown offic shot know brown time | 4.68% |
| Topic 8: ferguson polic outsid protestor report mikebrown shoot protest dept peopl | 4.68% |
| Topic 9: brown polic michael ferguson robberi let store confer press pack | 4.68% |
| Topic 10: ferguson differ murrieta patriot proport mikebrown mike black bundyranch direct | 4.68% |

Cluster 3:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: amp yesterday franc path toll today flight crash germanw everyth | 3.10% |
| Topic 2: photo germanw crash depress victim pilot airport area show arriv | 3.10% |
| Topic 3: crash germanw plane franc french airbus alp southern break flight | 3.10% |
| Topic 4: passeng crew thought board amp germanw six lufthansa say member | 3.10% |
| Topic 5: crash germanw fear survivor presid expect plane dead say holland | 3.10% |
| Topic 6: germanw crash plane french flight airbus pilot break alp franc | 72.06% |
| Topic 7: feet posit last flight flightradar lost utc rapid germanw show | 3.10% |
| Topic 8: signal distress germanw aviat send french say alp afp crash | 3.10% |
| Topic 9: germanw latest nov famili crash serial episod french bild number | 3.10% |
| Topic 10: emerg call distress germanw thought flight famili logo last break | 3.10% |

Cluster 4:

| Topic | Dominance Percentage |
|---|----------------------|
| Topic 1: goe corneliusgurlitt grutter marinello organis evalu read part paint psychiatr | 2.98% |
| Topic 2: museum bern accept collect swiss art cornelius nice amaz bogardthat | 2.98% |
| Topic 3: hors late artwork announc accept face recoveri loom gurlitt chronicl | 2.98% |
| Topic 4: accept gurlitt museum challeng decid last bern swiss consid neverforget | 2.98% |
| Topic 5: gurlitt art museum swiss accept collect bem nazi trove bequest | 73.21% |
| Topic 6: seem bern gurlitt swi museum litig one back announc cultur | 2.98% |
| Topic 7: artsbeat era art transfer gurlitt artwork nazi possibl overlook propos | 2.98% |
| Topic 8: art weird gurlitt situat handl nazi wrong hoard curat via | 2.98% |
| Topic 9: art collect confirm accept swiss follow design gurlitt challeng dealer | 2.98% |
| Topic 10: swiss challeng museum cousin exclus thicken judg gurlitt say let | 2.98% |

Cluster 5:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: ottawa shoot parliament shot soldier ottawashoot polic hill memori war | 77.21% |
| Topic 2: area ottawa protect sorri capit parliament avoid secur amp hill | 2.53% |
| Topic 3: silenc fear moment ottawashoot damn polit honor anaheim held pleas | 2.53% |
| Topic 4: hospit patient stabl ottawashoot ottawa condit hero receiv vicker kevin | 2.53% |
| Topic 5: parliament coverag shoot live watch hill insid video shot ottawa | 2.53% |
| Topic 6: ottawa thought everyon prayer today stay shoot safe downtown polic | 2.53% |
| Topic 7: cirillo nathan soldier kill cpl ottawashoot shot ottawa identifi memori | 2.53% |
| Topic 8: photo scene michael bibeau zehaf ottawa ottawashoot shoot room caucus | 2.53% |
| Topic 9: cenotaph muslim ottawa citi soldier close event world ottawashoot war | 2.53% |
| Topic 10: year shoot old michael canada reservist six justin bieber son | 2.53% |

Cluster 6:

| Topic | Dominance Percentage |
|--|----------------------|
| Topic 1: putindead putin death die win dead comvlad start internet event | 2.77% |
| Topic 2: putindead dead putin never moscow may specul punk even london | 2.77% |
| Topic 3: disappear mean coup could putin vladimir undergo russia tcot expert | 2.77% |
| Topic 4: putin coup vladimir russia continu palac might putindead sourc mean | 2.77% |
| Topic 5: putin putindead coup russia kremlin moscow vladimir putinmiss disappear via | 75.10% |
| Topic 6: kremlin russia news putin someth miss militari putindead moscow coup | 2.77% |
| Topic 7: palac putin indic coup absenc moscow question putindead via whereisputin | 2.77% |
| Topic 8: putin day fend coup polit russia updat putindead vladimir cou | 2.77% |
| Topic 9: putindead putin russia coup take thicken whereisputin activist alien peopl | 2.77% |
| Topic 10: putindead kabayeva putin moscow photo mistress given today kremlin Russia | 2.77% |

Cluster 7:

| Topic | Dominance Percentage |
|--|-----------------------------|
| Topic 1: sydney love safe sydney sieg illridewithyou everyon everyth hope prayforsydney situat | 3.08% |
| Topic 2: closer citi report break caption australian confirm sydney sydney sieg becom | 3.08% |
| Topic 3: life reevalu need true line outsid shit pray today sydney | 3.08% |
| Topic 4: price hike passeng uber sydney sieg surg wish martinplacesieg minimum mother | 3.08% |
| Topic 5: male flag conscious ave crew balconi thrown cigarett smoke coquitlam | 3.08% |
| Topic 6: sydney sydney sieg hostag cafe polic break peopl sieg report flag | 72.26% |
| Topic 7: sydney sieg thought peac prayer sydney abbott toni hostag peopl mosqu | 3.08% |
| Topic 8: condemn statement mufti issu grand sydney sieg friend prayer australia hostag | 3.08% |
| Topic 9: sydney sieg islam terror martinplac period sick societ selfi sydney take | 3.08% |
| Topic 10: write media either hand public arab degre strip sydney sieg least | 3.08% |

