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Adding a Capability to Extract Sentiment from Text using HanDles

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Defence R&D Canada
Technical Memorandum
DRDC Toronto TM 2012-063
May 2012

Canada

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DRDC Toronto TM 2012-0632012-063

May 2012

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Abstract

HanDles is a document visualization tool developed by Ohio State University for DRDC Toronto. One aspect of documents that might be of interest to analysts is the extent to which they express positive or negative opinion or sentiment toward some issue or group. In this report, we describe how HanDles was extended to include the ability to classify documents as containing predominantly positive or negative sentiment. To do so, we trained the semantic model underlying HanDles' understanding of the document collection to distinguish positive from negative documents. Our tests of the system suggested that its ability to discriminate positive from negative documents would be greatly improved by selecting a training collection that is similar in nature and content to the documents that will be evaluated in operational settings.

Résumé

HanDles est un outil de visualisation de documents conçu par l'Ohio State University pour DRDC Toronto. Une caractéristique des documents qui peut s'avérer intéressante pour les analystes est l'importance de l'opinion positive ou négative que dégagent ces documents à l'égard de certaines questions ou de certains groupes. Dans le présent rapport, nous décrivons comment nous avons amélioré HanDles afin qu'il prenne en charge la classification de documents selon la prédominance, dans leur contenu, de sentiments positifs ou négatifs. Pour ce faire, nous avons formé la compréhension du modèle sémantique sous-jacent à HanDles quant au recueil de documents utilisé afin qu'il soit en mesure de distinguer les documents positifs de ceux qui sont négatifs. Nos essais du système nous poussent à croire qu'il est possible d'accroître considérablement sa capacité à différencier les documents selon le sentiment qui s'en dégage en choisissant un recueil de formation dont la nature et le contenu ressemblent à ceux des documents qui seront évalués dans un contexte opérationnel.

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Executive summary

Adding a Capability to Extract Sentiment from Text using HanDles:

**Peter Kwantes; Benjamin Stone; Jihun Hamm; Peter Kwantes; DRDC Toronto
TM 2012-0632012-063; Defence R&D Canada – Toronto; May 2012.**

Introduction or background: HanDles is a document visualization tool developed for DRDC Toronto as part of ARP project 15ah. In this project, HanDles was augmented with the capability to classify documents as expressing either positive or negative sentiment. The capability was added to the tool so that it could be used in Influence Operations contexts in which analysts want to measure the extent to which issues or groups of interest are viewed favourably or unfavourably. As a test case, we trained HanDles to distinguish good and poor film reviews, and then tested it three times to see how well it classified documents. The first test was conducted on reviews of the Amazon Kindle. The second test was run on text segments of the original training set of movie reviews, and finally, it was tested on a set of movie reviews that it had not seen before.

Results: In general, HanDles did a poor job detecting the sentiment associated with the reviews of the Amazon Kindle. We attribute the poor performance to the fact that movie and product reviews discuss different issues, and as such, there will be limited similarity in the two classes of document. Not surprisingly, HanDles did a good job classifying text segments of the original training set. However, the finding demonstrated that, unlike many other sentiment analysis tools that only classify text at the whole-document level, HanDles can be used effectively to extract the issues being discussed within documents, and assign sentiment to those. For example, a review of a film might be classified as negative overall, but HanDles can determine that, for example, the *acting* was good, but the *directing* was poor. Finally, when we tested HanDles on a new set of movie reviews it had not seen before, it performed with 93.3% accuracy.

Significance: The results of our trial suggest that HanDles could represent a powerful tool for extracting sentiment and other kinds of higher-level properties from reports or intercepted media. What will be vital however, is that the system first be trained on the right kinds of documents. In other words, there must be some similarity between the documents used during training and those used in the operational context in order for it to work properly.

Future plans: To transition HanDles into operational use, DRDC and CF stakeholders must decide on what the most appropriate documents are for training the system to tell the difference between positive and negative opinion in text. Once a class of document has been decided, we can proceed to train it and trial the system in a more realistic context.

Sommaire

Adding a Capability to Extract Sentiment from Text using HanDles:

**Peter Kwantes; Benjamin Stone; Jihun Hamm; Peter Kwantes DRDC Toronto
TM 2012-0632012-063 ; R & D pour la défense Canada – Toronto; mai 2012.**

Introduction ou contexte : HanDles est un outil de visualisation de documents conçu pour RDDC Toronto dans le cadre du PRA 15ah. Dans ce projet, nous avons ajouté dans HanDles la capacité de classifier les documents selon l'impression positive ou négative qui s'en dégage. Nous avons apporté cette amélioration afin de pouvoir utiliser cet outil dans le cadre d'opérations d'influence au cours desquelles des analystes souhaitent mesurer l'importance des opinions favorable et défavorable envers des problèmes ou groupes d'intérêt donnés. Au cours du scénario d'essai, nous avons formé HanDles afin qu'il fasse la distinction entre bonnes et mauvaises critiques de film. Nous avons exécuté ce scénario à trois reprises dans le but de vérifier à quel point il parvient à classifier correctement les documents. Le premier essai portait sur des critiques de l'appareil Kindle d'Amazon. Le deuxième se concentrait quant à lui sur des extraits de textes tirés du recueil de critiques de film de formation. Finalement, nous avons effectué le troisième essai à l'aide d'un recueil de critiques de film qu'HanDles n'avait jamais traité auparavant.

Résultats : Dans l'ensemble, HanDles ne parvient pas vraiment à détecter le sentiment associé aux critiques du Kindle. Nous attribuons ce piètre rendement au fait que les critiques de films et d'appareils traitent des questions différentes, et donc qu'il n'y a que peu de similarités entre ces deux catégories de documents. Comme nous nous y attendions, il a effectué un bon travail quant à la classification des segments de texte provenant du recueil de formation. Cependant, nos résultats démontrent que, contrairement à de nombreux autres outils d'analyse d'impressions qui n'effectuent que la classification de textes complets, HanDles est en mesure d'extraire correctement les points traités dans les documents et de leur attribuer un sentiment. Par exemple, dans le cas d'une critique de film classifiée comme étant négative dans l'ensemble, il peut déterminer que le *jeu des acteurs* était bon, mais la *réalisation*, médiocre. Finalement, lorsque nous avons mis HanDles à l'essai à l'aide d'un recueil de critiques de films qu'il n'a jamais traité auparavant, il a classifié les documents avec une exactitude de 93,3 %.

Signification : Les résultats obtenus lors de nos essais nous portent à croire que l'outil HanDles pourrait constituer un puissant outil permettant d'extraire les sentiments émanant de rapports ou de médias interceptés. Il est cependant primordial de former le système à l'aide des bons types de documents. En d'autres mots, pour que cet outil fonctionne adéquatement, il doit y avoir certaines similarités entre les textes employés au cours de la formation d'HanDles et ceux traités dans un contexte opérationnel.

Plans pour l'avenir : Pour effectuer la transition d'HanDles vers un environnement opérationnel, les intervenants de RDDC et des FC doivent décider quels sont les documents les plus appropriés à la formation du système afin qu'il soit en mesure de bien discerner les opinions positives de celles négatives. Lorsqu'ils auront choisi une catégorie de texte, nous pourrions procéder à la formation et à la mise à l'essai du système au sein d'un environnement plus réaliste que ceux utilisés jusqu'à présent.

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Acknowledgements

This work was conducted as a Work Breakdown Element (15ah02) of Applied Research Project 15ah.

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1 Introduction

1.1 Purpose of the work

Traditional information retrieval mechanisms focus on the content of a document--that is, the issues that the document raises. Just as critical in many intelligence and Influence Operations contexts is the stance that the author takes with respect to those issues, or how that author feels about them. The area of automated opinion mining and sentiment analysis (OMSA) uses natural language processing and machine learning techniques to classify documents into positive and negative classes. The objective is to facilitate an analyst's task in identifying critical documents to study from large collections and to provide a global view of the sentiment expressed across the documents.

The purpose of this work was to introduce a sentiment analysis mechanism into the HanDles document visualization tool.

1.1.1 Integrating OMSA into the HanDles Tool

HanDles provides a search interface to a document set and three visualizations to allow participants to quickly assimilate large document collections. The first of these visualizations is a typical results set as would be returned from an Internet search engine such as Google or Bing. In addition, however, HanDles provides a set of automatically generated tags known as *handles*, that allow the user to quickly select subsets of documents of interest. The second visualization plots a projection of a semantic space derived from the documents. Both handles and documents are plotted with proximity coding for semantic similarity. Rather than provide a static display, however, handles and documents can be dragged to interactively modify the view of the space afforded to the user. Finally, a timeline view plots the popularity of different handles as a function of time.

To integrate OMSA into the tool two special handles titled "Positive Sentiment" and "Negative Sentiment" were added. The user can choose to have these handles displayed by clicking on a sentiment link in the Search Options box on the main results page of the tool. The positive and negative handles then become available in all three views of the interface. In the document view, they allow the user to quickly highlight either the positive or negative documents, so that they can scan those quickly. This view also provides counts of the positive and negative documents, allowing the user to rapidly assess the general sentiment towards the topic for which they searched in the document set.

In the space view, handles expressing content issues can be arranged around the screen. For instance, if you were a market researcher examining reviews of the Amazon Kindle you might arrange issues like page turning, battery life, customer support, and other aspects around the screen. Selecting one of the sentiment-labeled handles then highlights the documents that are classified with that sentiment. The distribution of those highlighted documents makes it visually apparent how sentiment is distributed across those issues. In the Kindle example, this would allow you to quickly determine not only that customer support is an issue of interest to the reviewers, but also whether they were positively or negatively disposed towards Amazon's

support. The way in which handles cluster also highlights the hot spots that might require more detailed study. At any time, a user can click directly on the dot representing a document to deepen their investigation.

In the timeline view, the positive and negative handles can be used to trace how sentiment has changed as a function of time. This function is critical in operations in which one is attempting to change the sentiment expressed by authors to monitor the success of those programs.

In many cases, operating at the level of entire documents (news articles, movie reviews etc.) is too coarse. Within a document many issues may be raised and the sentiment expressed towards each issue may not be the same. A movie reviewer might have liked the plot, but think that the acting left something to be desired, for instance. To capture this, HanDles allows one to divide documents into subdocuments of fixed length. The main results screen provides a box in which one can specify how many words will be contained in these document fragments.

1.1.2 The Classifier

The ability to effectively use the sentiment mechanisms deployed in HanDles tool relies on the accuracy of the sentiment classifier. There has been a recent surge in work on sentiment classification, based in part on the provision of large sets of documents labeled with sentiment. In particular, Pang and Lee (2004) provided a movie review dataset consisting of 1000 positive and 1000 negative reviews crawled from the Internet Movie Database (IMDB) movie archive, with an average length of 30 sentences.

The algorithm we used to classify documents into positive and negative classes is called a Support Vector Machine (SVM). Simply put, an SVM examines a large collection of documents that have already been classified as positive or negative, and tries to work out the function that best differentiates them. After training, the SVM uses the function it has decided upon to classify new documents as being either positive or negative in tone or sentiment.

To try to achieve maximum accuracy, generalization and speed, we used only words that appeared in a polarity dictionary (from He, Lin and Alani, 2011) that appeared at least 50 times in the corpus and employed a pure discriminative classifier. We initially, tried libSVM from the Shogun machine learning package (Sonnenburg et. al. 2010). With it, we obtained accuracy of 89.7% on positive examples and 65.2% on negative examples, for an average of 77.1%. Given that performance on the negative examples was low, we switched to the Generalized Minimum Norm Problem SVM (Franc, 2005). This classifier produced accuracies of 87.6% on positive examples, 83.8% on negative examples, for an average performance of 85.7%, which was acceptable.

It is worth noting that some authors have reported accuracy in excess of 95% on this dataset using a combination generative graphical model plus support vector machine (SVM) approach (He, Lin & Alani, 2011). Part of the work involved in the contract under which this work was carried out was an attempt to recreate the high level of accuracy reported by He et al. Several attempts using different parameterizations failed to reproduce the very high accuracy reported by He et al, and as a result, those enhancements to the classifier were not implemented in the final product discussed here.

1.1.3 Evaluation

As an initial test, we tried the sentiment analysis mechanism on a set of reviews of the Amazon Kindle that were extracted from the Amazon website. It quickly became apparent that the classifier did not generalize well to these documents, with many misclassifications immediately obvious. We do not have ground truth labels with which to quantify the performance on this dataset, but it is clear that generalization across domains will be difficult. Note that we used a restricted vocabulary of polarity laden terms, which should help to improve generalization, and yet performance was disappointing. It may be necessary in the future to train classifiers for specific domains and/or to work to improve the vocabulary of polarity words.

The screenshot displays a web application interface for document management and sentiment analysis. The top navigation bar includes icons for Documents, Space, Time, and Help, along with a Home button and a search bar containing "Sentiment102 AND 'Star Wars'". A "Go" button is next to the search bar. On the right, there are links for Reports, Manager, and a Welcome message for Ben with a Logout link.

The main content area is divided into two columns. The left column, titled "HANDLES", shows a list of 1214 handles (0 of 1214) with a count next to each handle. The handles are color-coded and include terms like "star wars", "special effects", "phantom menace", "obi wan", "qui gon", "george lucas", "science fiction", "star trek", "starship troopers", "obi wan kenobi", "darth vader", "liam neeson", "toy story", "anakin skywalker", "star wars episode", "natalie portman", "star wars trilogy", and "jake lloyd".

The right column displays the sentiment analysis results for three specific documents, each identified by a handle (cv953_6836p1, cv953_6836p2, cv953_6836p3). Each document entry includes a paragraph of text with words highlighted in color (red for "star wars", green for "science fiction", blue for "special effects", and yellow for "PositiveSentiment"). Below the text, there is a "Doc ID" and a "Sentiments" section with radio buttons for "None", "All (2)", and "Other...".

A "SEARCH OPTIONS" panel is located on the right side of the interface, containing fields for "No of Documents" (set to 200), "Max Document Word Size" (set to 50), "No of Handles" (set to 30), "Start Date", "End Date", and "Sentiments". A "Less..." link is at the bottom of the panel.

Figure 1 Documents View, 67 "Star Wars" movie reviews have been split into document size 50, resulting in 1214 handles documents.

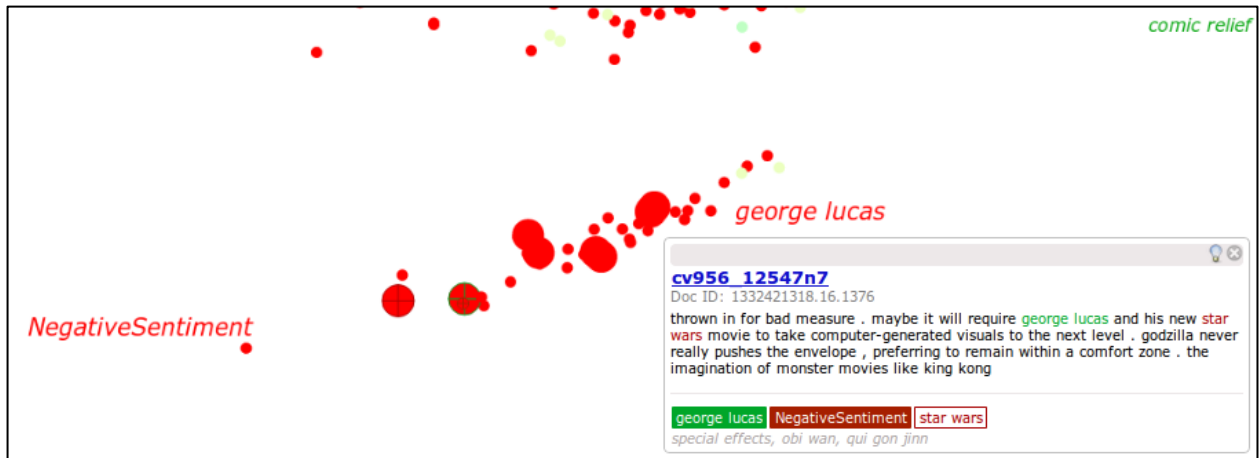


Figure 3 Negative Sentiment and “George Lucas”.

One of the difficulties that presents itself in when attempting to extract sentiment out movie review documents, is the context of the sentiment. A good example of this problem is displayed below in Figure 6. The text fragment that has been open reads:

“senate to make an appeal for justice . on tatooine , qui gon discovers a young slave boy , anakin skywalker (jake lloyd) , who not only can help them get the parts they need , but displays uncanny intelligence , insight , and instincts . qui gon senses the”

In this example the classifier has labeled the document as containing Positive Sentiment, and to some extent this is true because the descriptive terms “uncanny intelligence”, “insight” and “instincts” are both desirable and positive qualities to attribute to someone. The problem with classification lies in the context or role of the author. In this case, the author adopts the role or voice of “story teller”, rather than the voice of a movie reviewer whose sentiment and opinions we were initially interested in polling. While the problem of distinguishing the author's voice is more likely to occur in reviews of movie or books, it is still possible it could occur in other datasets.

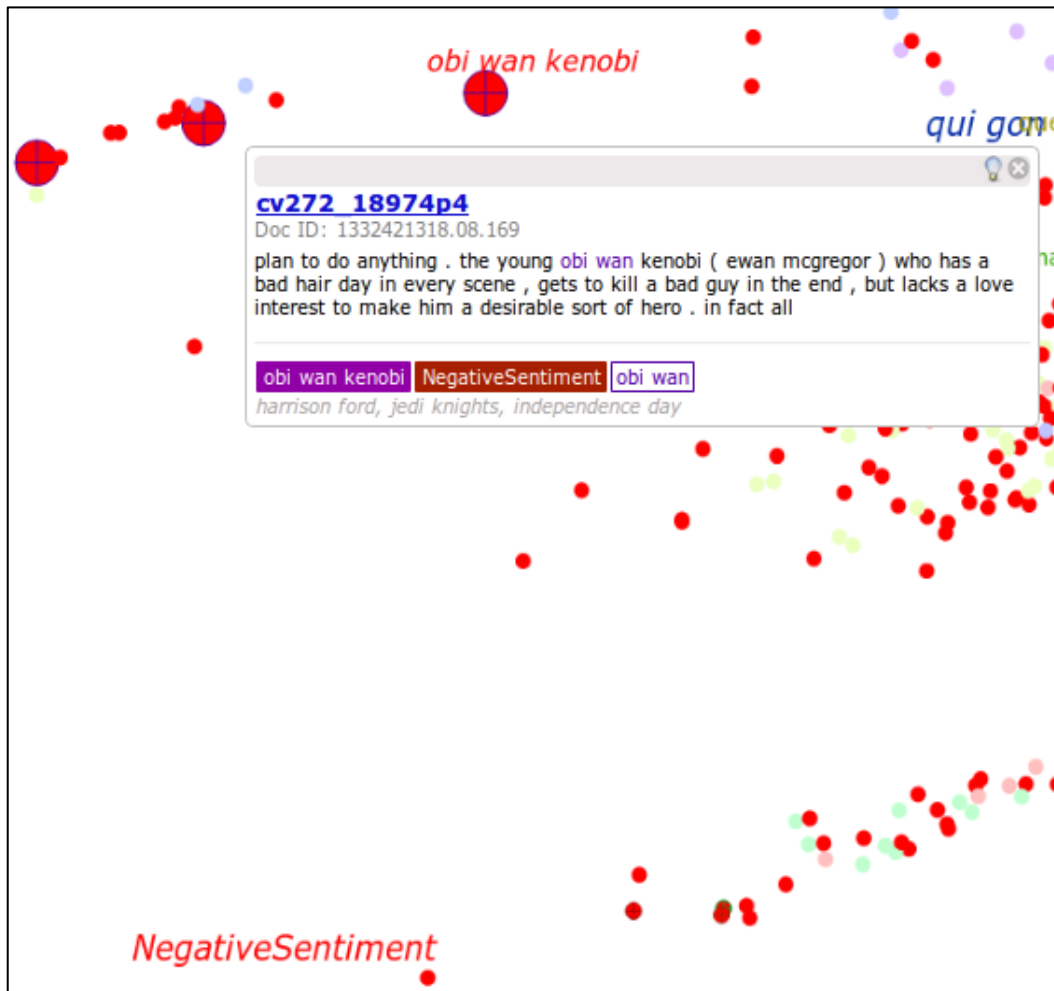


Figure 4 Negative Sentiment and “Obi Wan Kenobi”

Another potential problem that is unique to the handles interface is displayed in Figure 7. Ideally, a request to HanDles for “Star Wars” movie reviews would only return those reviews that are about the six Star Wars movies; however, this is not the case. There are many different movies reviewed in Pang and Lee's (2004) dataset, some of which are not reviewing a Star Wars movie, but do reference the Star Wars movies. For example, one of the reviews of the film Toy Story mentions a parody of Star Wars made by that movie. Another review compares the film, Starship Troopers to Star Wars saying that “Starship Troopers is very reminiscent [sic] of star wars , another kick-ass space opera”. While returning these documents is not necessarily a bad thing (the user may wish to know all references about a subject), it is worth the user bearing in mind that these types of documents may be returned by HanDles.

The Pang and Lee's (2004) dataset does not have dates associated with the individual movie reviews, so it is not possible to view sentiment in the Timegraph view. This was unfortunate, as viewing handles (of which Sentiment is one) over time is a very informative feature of the HanDles application.

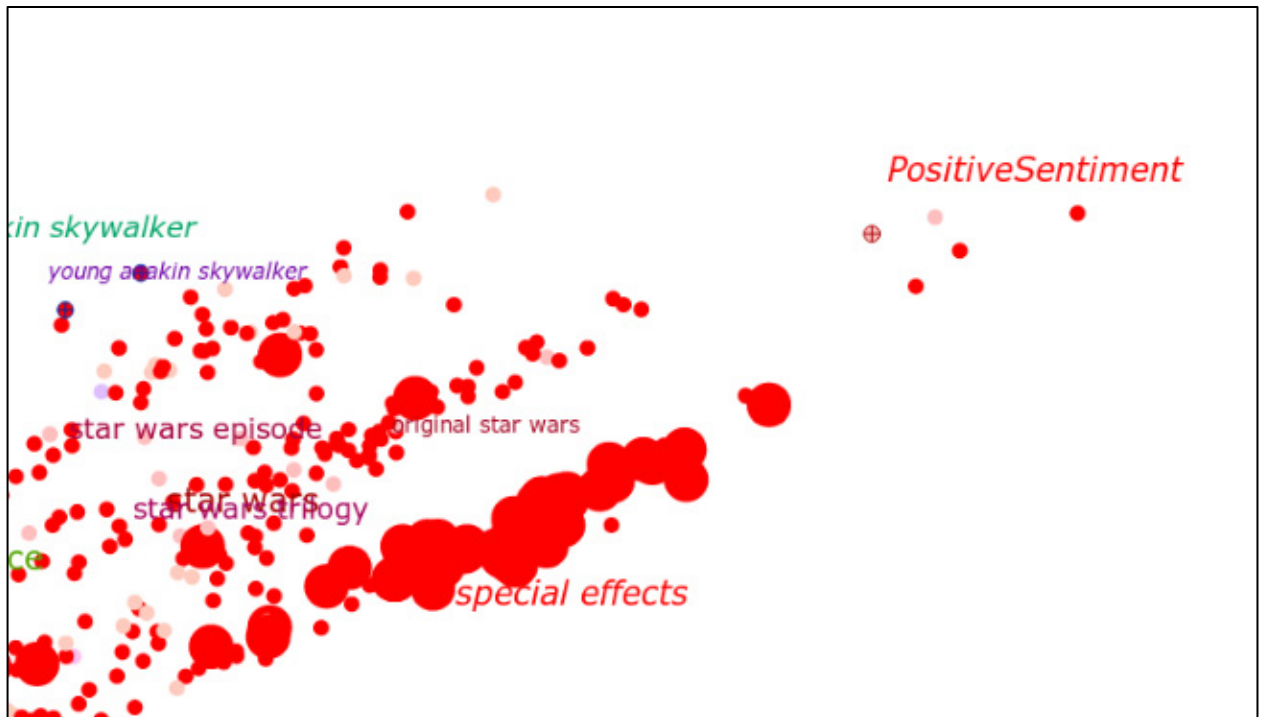


Figure 5 Positive Sentiment and “Special Effects”.

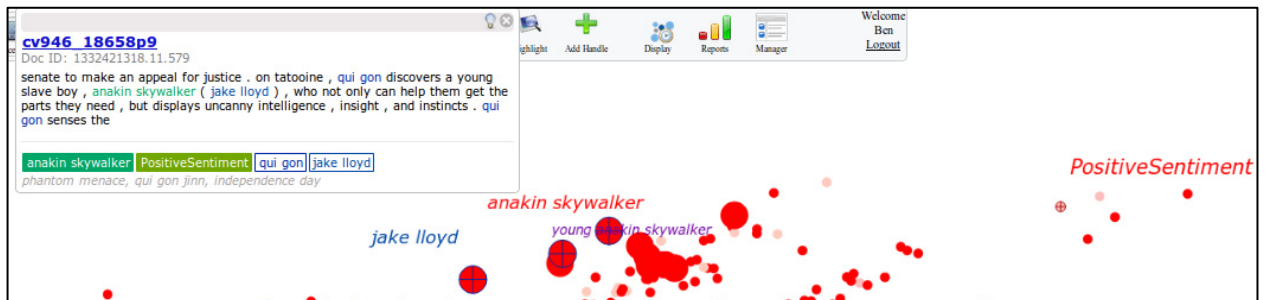


Figure 6 The potential problem of context for Sentiment Classification



Figure 7 The problem of “non Star Wars” reviews that mention “Star Wars”.

It should not come as a surprise that, in the above test of the capability, we obtained acceptable results when we used movie reviews taken from the training set. In a second test of the system, we selected 30 movie reviews written by IMDB users. Fifteen of the reviews were taken from a list of the worst movies ever made (*LOL*, *Jack And Jill*, *Meet The Spartans*, *Titanic*, *Dragonball*, *Epic Movie*, *Vampires Suck*, *Spy Kids*, *Disaster Movie*, *Catwoman*, *Bucky Larson*, *The Room*, *Battlefield Earth*, *Superbabies*, *The Hottie And The Nottie*) and 15 from a list of the best movies ever made (*Shawshank Redemption*, *The Dark Knight*, *Lord of the Rings*, *Inception*, *Se7en*, *Spirited Away*, *A Separation*, *Toy Story 3*, *The Lives Of Others*, *The Untouchables*, *Wall-E*, *Braveheart*, *Pan's Labrynth*, *Batman Begins*, *Gran Torino*). Figure 8 shows the film titles in the HanDles map. As a next step, we moves the PositiveSentiment and NegativeSentiment handles to opposite corners of the screen. Doing so causes the movie title on the screen handles to follow the most strongly associated sentiment handle. Then, to further separate the them, we continuously click or, “pump” the positive and negative sentiment handles to draw associated titles closer. As is clear in Figure 9, HanDles does an impressive job of differentiating good and poor reviews. HanDles did make two interesting misclassifications, however. It mistakenly classified the review for the Clint Eastwood film, *Gran Torino* as negative and the Adam Sandler flop, *Jack and Jill*, as positive (see Figure 10). An examination of the narrative in the reviews clarifies how the misclassification occurred. *Gran Torino* is a film about a grumpy, foul mouthed man and as such, the film’s description contains many terms that are generally associated with negative sentiment like, for example, foul, racist, dirty (as in *Dirty Harry*) racist, complaints, and garbage. In essence, the negative terms contained in the text misled the classifier.

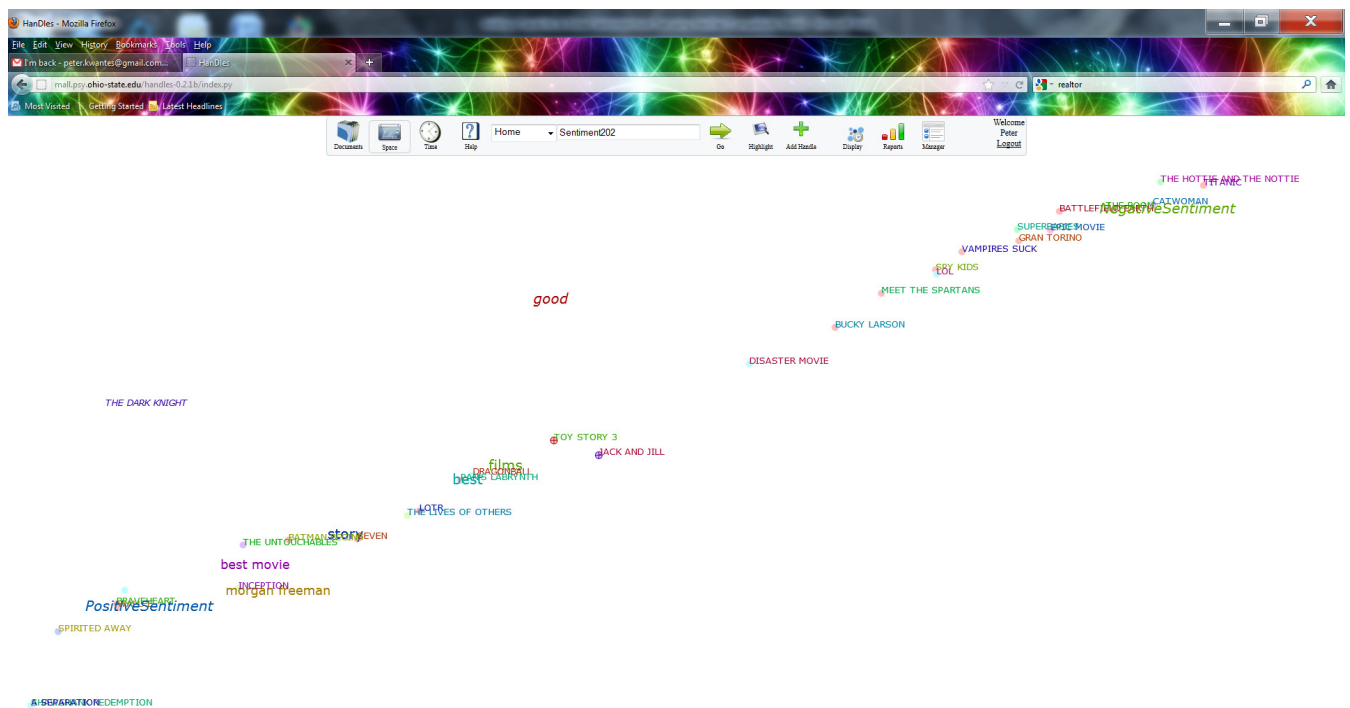
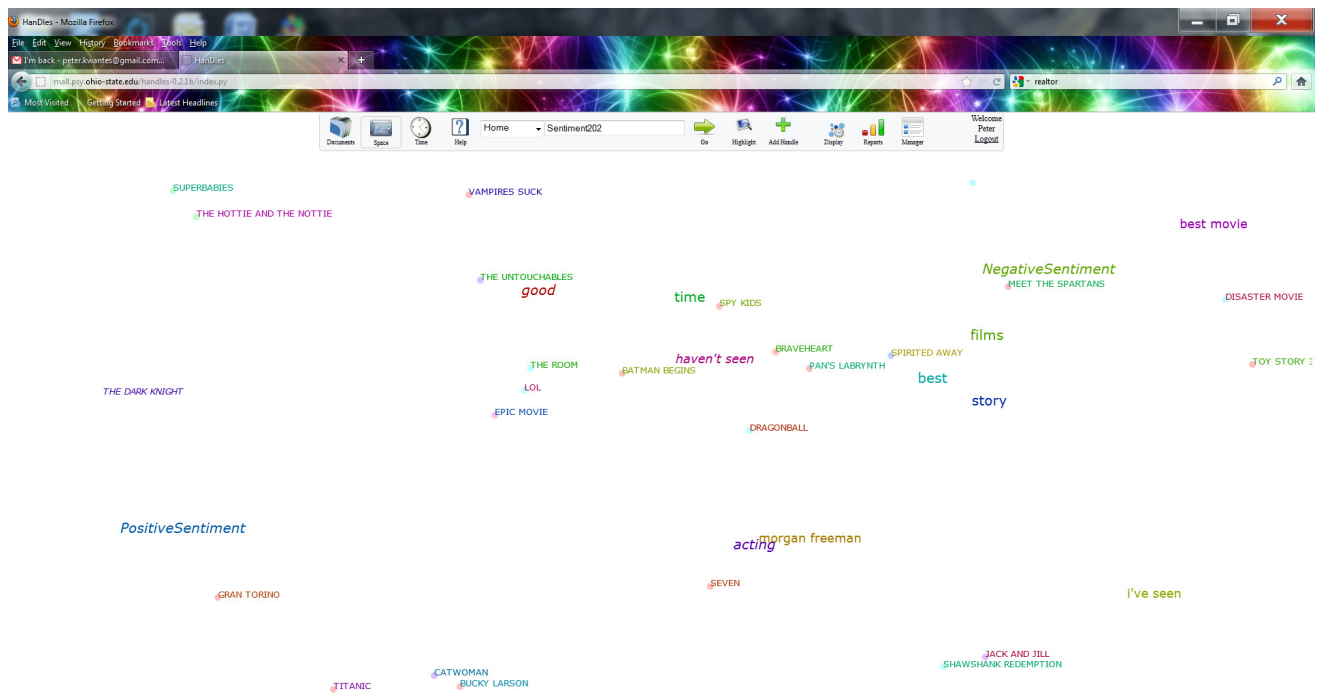
“With his performance Eastwood shows you why people like himself, Jack Nicholson, or Paul Newman only come around once in a lifetime. Though Eastwood would rather focus on directing, he can still carry a movie with his on screen presence, and he's pure dynamite in "Gran Torino". Perhaps the poor box office results of "hollywoody" movies like Absolute Power, True Crime, Space Cowboys, and Blood Work, caused Eastwood to shy away from acting, but given cutting edge material to work with as "Million Dollar Baby" and "Gran Torino", he's as good as ever. His character as the racist and salty war vet makes you think of that old guy we've all had on our blocks with the garbage (sic) door open, the million tools hanging everywhere, and always fixing or building something. I found myself not wanting the movie to end because the scenes between himself and the various Hmong characters were priceless. There may be complaints over the racist remarks and scenes, but

Eastwood pulls it off in a way a real person like that would talk or act to a point where it ends up being lighthearted. I'm not going to give the plot away, but if you like your Clint Eastwood as a hard-nosed tough guy with foul language alla Dirty Harry or Heartbreak Ridge, you'll love this movie!!"

On the other hand, the film, *Jack and Jill* was classified as containing positive sentiment, despite the review being clearly scathing.

"I will start by saying that I have enjoyed many Adam Sandler movies and have found him to be a generally funny guy when I've seen him interviewed and when he was on Saturday Night Live. I laughed gleefully through Anger Management, Mr. Deeds, Billy Madison, 50 First Dates, and Happy Gilmore. Funny People and Just Go With It were awesome movies! I was brought to tears in Sandler's emotional portrayal in Reign Over Me. I have great respect for the man as a comedian and actor. But Jack and Jill is abysmal. The "jokes" are not only bizarrely misplaced - THEY ARE NOT FUNNY. I did not hear a single laugh, not even a slight giggle from any audience member in the theater. In fact, almost 1/3 of them walked out before it was over. Those who stayed, openly derided the flick as we all exited the theater in utter disgust and sadness. I don't know why Al Pacino was in this movie, his acting made it seem like he was forced at gun point to do this movie. Nick Swardson and Tim Meadows are way too funny to be in such a disaster. Especially given Swardson's stellar performance in Just Go With It. This movie is not a flop, its not an "oops", its not a mistake - it's a career ending pile of trash. A career ender that started with Sandler's god awful "Grown Ups" and climaxes with this revolting hunk of garbage. Sorry Adam, it's over."

Here again, the film's review is clearly negative, but the document contains several positive terms like, funny, laughed, gleefully, Happy, respect, funny (interestingly, "funny" appears in the phrase "not funny"), laugh, giggle, and stellar. A document's classification is made by weighing its positive and negative aspects, and in this case, there was clearly enough positive sentiment expressed in the review to mislead the classifier.



2 Conclusion and Recommendations

The most important finding presented in this report is that it will be necessary in the future to train classifiers for specific domains and/or to work to improve the vocabulary of polarity words used by HanDles or any other mechanism that could be used to automatically classify documents according to their sentiment. In particular, the classifier should be trained on documents that are similar to those which will be examined in operational settings. For example, in an Influence Operations context, CF analysts may be interested in measuring positive and negative sentiment expressed by locals toward local governance or the Canadian Forces. Movie reviews do not provide the ideal class of document with which to train a sentiment analysis system. Instead, a large document collection comprising text written for and by members of the local population would be most appropriate. To this end, it is important to decide at the beginning of an influence operation, what kinds of documents from the area of operations should be gathered and submitted to the system.

Another conclusion from the work reported here is that the ability to divide the documents is a critical capability of Sentiment Analysis in HanDles, so future development work in this area would be of benefit to the HanDles system. Traditional sentiment analysis applies positive and negative classifications to whole documents. As we demonstrated above however, such a coarse level of analysis will often fail to capture what aspects of the topics under discussion are written about positively or negatively. For example, the review of *Jack and Jill* above is decidedly negative, but contains positive sentiment when discussing its cast. HanDles' ability to subdivide documents allows it to detect the sentiment associated with various topics discussed in a document—a capability not common to tools of this sort, but nonetheless critical for accurate situational awareness and measurement of a campaign's effectiveness in operational settings.

HanDles is ready for exploitation. The next step in its transition to operational use will be the generation of an appropriate collection of documents to use for training the system to distinguish documents expressing positive and negative sentiment. To do so however, DRDC and CF personnel from the Intelligence and Influence Activities context will need to work together to decide on where those documents will come from.

Sentiment is one of several kinds of classification that can be applied to documents. In future, we can envisage other forms of discrimination being introduced to the tool. For example, the SVM in HanDles could be trained to automatically distinguish threatening from non-threatening narrative in blogs or violent from non-violent events described in intelligence or situation reports. The point is that the SVM is a generic classifier, and can be trained to classify documents on any dimension so long as the documents in the training set have ground-truth labels.

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List of symbols/abbreviations/acronyms/initialisms

DND	Department of National Defence
DRDC	Defence Research & Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
R&D	Research & Development
OMSA	Opinion Mining and Sentiment Analysis
SVM	Support Vector Machine
IMDB	Internet Movie Database

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DOCUMENT CONTROL DATA		
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5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)	6b. NO. OF REFS (Total cited in document.)
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HanDles is a document visualization tool developed by Ohio State University for DRDC Toronto. One aspect of documents that might be of interest to analysts is the extent to which they express positive or negative opinion or sentiment toward some issue or group. In this report, we describe how HanDles was extended to include the ability to classify documents as containing predominantly positive or negative sentiment. To do so, we trained the semantic model underlying HanDles' understanding of the document collection to distinguish positive from negative documents. Our tests of the system suggested that its ability to discriminate positive from negative documents would be greatly improved by selecting a training collection that is similar in nature and content to the documents that will be evaluated in operational settings.

HanDles est un outil **de visualisation** de documents conçu par l'Ohio State University pour RDDC Toronto. Une caractéristique des documents qui peut s'avérer intéressante pour les analystes est l'importance de l'opinion positive ou négative que dégagent ces documents à l'égard de certaines questions ou de certains groupes. Dans le présent rapport, nous décrivons comment nous avons amélioré HanDles afin qu'il prenne en charge la classification de documents selon la prédominance, dans leur contenu, de sentiments positifs ou négatifs. Pour ce faire, nous avons formé la compréhension du modèle sémantique sous-jacent à HanDles quant au recueil de documents utilisé afin qu'il soit en mesure de distinguer les documents positifs de ceux qui sont négatifs. Nos essais du système nous poussent à croire qu'il est possible d'accroître considérablement sa capacité à différencier les documents selon le sentiment qui s'en dégage en choisissant un recueil de formation dont la nature et le contenu ressemblent à ceux des documents qui seront évalués dans un contexte opérationnel.

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Handles; document visualization; sentiment analysis; opinion mining

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