VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

SUMMARIZING ELECTRONIC THESES AND DISSERTATIONS (ETD)

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Team 17
Ashin Marin Thomas
Chinmaya Patnayak
Dhruv Sharma
Farnaz Khaghani
John Aromando
Instructor: Prof. Edward A. Fox
Department of Computer Science, Virginia Tech, Blacksburg, Virginia - 24061

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ABSTRACT

Given the current explosion of information over various media such as electronic and physical texts, concise and relevant data has become key to the understanding of things. Summarization, which essentially is the process of reducing the text to convey only the salient aspects, has emerged as a challenging task in the field of Natural Language Processing. In a scientific construct, academia has been generating voluminous amounts of data in the form of theses and dissertations. Obtaining the chapter-wise summary of an electronic thesis or dissertation can be a computationally expensive task, particularly because of its length and the subject to which it pertains to.

Through this course, research and development of various summarization techniques, primarily extractive and abstractive summarization, were analyzed. There have been various developments in the field of deep learning to tackle problems related to summarization and produce coherent and meaningful summaries for news articles. In this project, tools that could be used to generate coherent and concise summaries of long electronic theses and dissertations (ETDs) were developed as well. The major concern initially was to get the text from a PDF file of an ETD. GROBID and Scienceparse were used as pre-processing tools to carry out this task, and presented the text from a PDF in a structured format such as XML or JSON file. The outputs from each of the tools were compared qualitatively as well as quantitatively. After this, a transfer learning approach was adopted, wherein a pre-trained model was tweaked to fit to the task of summarizing each ETD. This came in as a challenge to make the model learn the nuances of an ETD. An iterative approach was used to explore various networks, each trying to improve the shortcomings of the previous one in itâĂŹs novel way. Existing deep learning models including Sequence-2-Sequence, Pointer Generator Networks and A Hybrid Extractive-Abstractive Reinforce-Selecting Sentence Rewriting Network were used to generate and test summaries. Further tweaks were made to these deep neural networks to account for much longer and varied datasets as compared to what they were inherently designed to work for – in this case ETDs.

A thorough evaluation of these generated summaries was also done with respect to golden standards for five dissertations and theses created during the span of the course. ROUGE-1, ROUGE-2, and ROUGE-SU4 were used to compare the generated summaries with the golden standards. The average ROUGE scores were 0.1387, 0.1224, and 0.0480 respectively. These low ROUGE scores could be attributed to the varying summary length, and also to the com-

plexity of the task of summarizing an ETD. The scope of improvements and the underlying reasons for the performance have also been analyzed. The conclusion that can be drawn from the project is that any machine learning task is highly biased by what pattern is inherently present in the data on which it is being trained. In the context of summarization, there can be different perspective from which an article can be summarized, and thus the quantitative evaluation measures can vary drastically even after the summary being a coherent one.

Keywords: Deep Learning, Abstractive Summarization, Electronic Thesis and Dissertation, Reinforcement learning

INTRODUCTION

Electronic theses and dissertations (ETDs) are among the most useful resources for researchers to refer to. However, the length of these documents is a limitation towards browsing and interacting with these valuable collections. To tackle this problem, we describe and design a framework to automatically extract a summary for each chapter and enhance comprehension of the documents. Our objective is to summarize the ETDs' chapters as an abstract for each chapter and its contents, using the deep learning approaches.

In general, there are two types of summarization methods: extractive and abstractive. In extractive methods, a summarizer tries to find and combine the most significant sentences from the corpus to form a summary. Abstractive Text Summarization (ATS) is the process of finding the most essential meaning of a text and rewriting it in a summary.

Most of the ETDs have been submitted in PDF format and may have different organization and formatting. Thus, the first step is to extract the content of each chapter for further analysis of the text. This step could create several challenges as there are various characters, figures, tables, or attributes like page number that should be removed to get the content of each chapter. It is also challenging to separate the chapters from the document as there is not a universal formatting for naming the chapters and numbering them. We take advantage of existing tools and libraries for parsing and cleaning our data. As all of the provided theses and dissertations are in PDF format, we first convert them to XML, and using the tags, remove the noise and extract the chapters.

When the cleaned content of each chapter is available, the modeling is going to take place. For this, we need reliable summaries to train our model based on them. This is one of the most challenging points of the project as the training sets have a significant influence on the performance of the model. Finding a proper training set is difficult since the training set should cover a broad range of the topics (as the ETDs are from different disciplines), they should be large enough, and include the satisfactory vocabulary set.

Given the different available approaches for modeling and text summarization, like statistical methods and natural language processing, in this work, we take a neural network approach. Due to the nature of our dataset and a wide range of topics and vocabulary that should be covered, we iterated over Seq2Seq and the Pointer Generator approach to identify

benefits and shortcomings of each. We started with the basic implementation, and based on the results, tuned the parameters of models toward improvement.

RELATED WORKS

Text Summarization

With the advancement in text mining and data analytics, there are numerous potentials to retrieve information from the texts of any kind. The tremendous amount of available text in recent years, thanks to the dramatic growth of the Internet, has been followed by demand for analysis of the texts to extract valuable information. Accordingly, this volume of text should be effectively summarized to generate knowledge. *"Automatic text summarization is the task of producing a concise and fluent summary while preserving key information content and overall meaning."* [4] There are two main paradigms for the text summarization task: abstractive and extractive. Extractive summarization techniques produce summaries by choosing a subset of the sentences in the original text. There are a large number of works in the literature proposing methodologies to automate the summarization task with an extractive approach [5, 6]. The abstractive approach involves rewriting the summary, is more like the way a human does the summarization task, and has seen substantial recent gains due to neural sequence-to sequence models [2, 7].

The first modern neural networks applied to abstractive text summarization achieving state-of-the-art performance on DUC-2004 and Gigaword, two sentence-level summarization datasets, was done by Rush et al. [8]. This was centered on the attention mechanism. This approach was followed by several other works employing recurrent decoders [9], hierarchical networks [10], or variational auto-encoders [11]. In one of the most recent efforts, Chen and Bansel proposed a hybrid abstractive-extractive architecture to combine the advantages of both abstractive and extractive methods by employing policy-based reinforcement learning (RL) [3]. Prior to this approach, which shares some high-level intuition with extract-then-compress methods, different approaches like Hidden Markov Models and rule-based systems [12], integer linear programming based methods [5], discourse structures [13], or graph cuts [14] have been investigated. For this project, we employ the Fast Abstractive Summarization approach [3] as an efficient approach for the text summarization task.

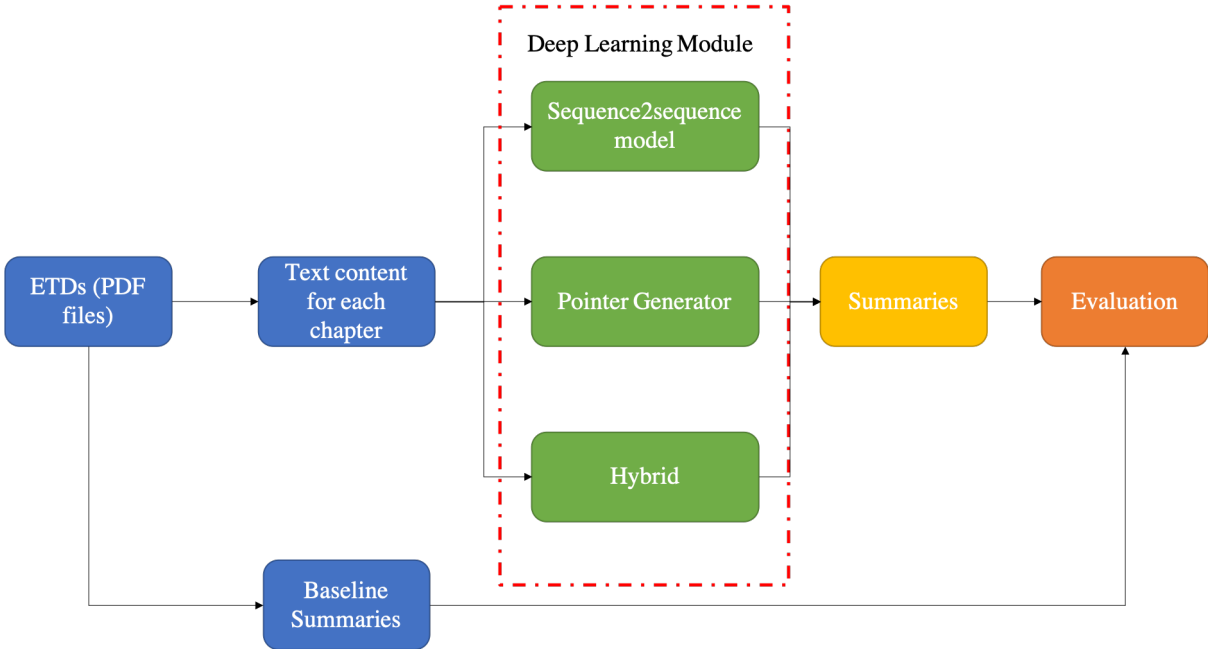


Figure 1: General framework of the tasks of ETD summarization

REQUIREMENTS

In this section, we describe the methodologies that are used for each step and the general architecture of our framework to meet the requirement of the project. The objective of this project is to build a framework that automatically generates a summary for each chapter of theses and dissertations. Figure 1 shows a general framework of our tasks in the current project.

Data Preprocessing And Text Extraction

The given dataset is a collection of theses and dissertations in the PDF format including 13071 dissertations and 17890 theses. The primary task for this part of the project is to pre-process the data and extract the text that needed to be summarized from the PDF documents. This task consisted of two other tasks: first, all the noise like figures, equations, or page numbers should be removed; second, the content of each chapter should be extracted from the text.

Deep Learning Modeling

While there are several methods for text summarization, such as Latent Semantic Analysis (LSA), Frequency-driven approaches, Topic words, or Bayesian Topic models, we take a deep learning approach for the text summarization task. At first, we need to review a set of existing models to understand complexities. We then deploy a sequence-to-sequence network to use as a baseline / reference model and rewire the network to account for changes in input data (format and length) and output structure. As the dataset with respect to the wide range of topics and vocabulary is a unique project, we need to explore different approaches and models to identify the complexities, challenges, and adjustments needed to be made for the project. Hence, after implementing the basic Seq2Seq model, we started working on two other approaches (pointer generator and hybrid summarization) in parallel.

DATA PREPROCESSING

As all of the provided documents are in the PDF format, the first step is to clean the documents and extract the text to be summarized. For this, we chose the GROBID library [15]. *"GROBID is a machine learning library for extracting, parsing and re-structuring raw documents such as PDF into structured TEI-encoded documents with a particular focus on technical and scientific publications"*. The structured format of XML helps to remove the noises easily. Tables and figures can be extracted and removed easily. Still, there are certain challenges using GROBID. It is too slow for converting the files into XML, not structuring the tags perfectly, and it is not able to extract the chapters.

Another option for parsing PDF files is Scienceparse [16]. Scienceparse is a tool that came up more recently than GROBID while it is inspired by GROBID. There are also challenges when parsing the PDF files using Scienceparse. For example, there are several dependency problems when using Scienceparse. Also, using Scienceparse is followed by memory issues compared to GROBID. With both pros and cons, we have tested both tools on our sample dataset to identify the capability of each for our project. We use the result from both as our baseline and for comparison purposes for our summary. The method we used is called the reduction method and is explained as follows: *"Graph-based summarization, where the saliences computed as the sum of the weights of its edges to other sentences. The weight of an edge between two sentences is computed in the same manner as TextRank."* An example of the summaries generated using Scienceparse and GROBID is shown in Figures 2 and 3

Research Questions and Main Findings of the StudyThe purpose of this study was to answer the following questions: The majority of participants responded that the VHSL should have the authority to impose periods of probation on coaches and sponsors, member schools and participants (73%), and prohibit the participation of coaches and sponsors, member schools, and participants (70%).The survey results suggest that the authority of the VHSL to perform such duties is supported by the majority of the groups that participated in this study.In addition to supporting the authority of the VHSL to impose periods of probation and the authority to prohibit participation, the majority of participants (59%) responded that the VHSL currently imposes penalties that are appropriate. Additionally, more Virginia legislators participated in the Polakiewicz study (21) when compared to the number of Virginia legislators who participated in this study (9) (Polakiewicz, 1985).A larger percentage of survey participants in the Polakiewicz study (87.6%) responded that the VHSL should have the authority to impose a period of probation upon coaches, member schools, and participants when compared to the survey results of this current study (73%) (Polakiewicz, 1985). Additionally, a larger percentage of survey participants responded that the VHSL should have the authority to prohibit the participation of coaches, member schools, and participants in the Polakiewicz study (79.9%) when compared to this current study (70%) (Polakiewicz, 1985).The majority of participants responded in the Polakiewicz study (57.2%) and this current study (59%) that the VHSL imposes penalties that are appropriate (Polakiewicz, 1985).Additionally, high school principals from the Polakiewicz study (67.4%) and high school principals from this current study (67%) responded that the VHSL imposes penalties that are appropriate (Polakiewicz, 1985).The results of this current study suggest that the VHSL should consider either an outside agency established by the Virginia Department of Education (10%) or an impartial fact-finding panel (46%) to hear appeals on VHSL decisions or disciplinary action. The survey results suggest that while there is satisfaction with how the VHSL is performing, the number of complaints received by participants has increased when compared to the Polakiewicz study.The majority of participants in the Polakiewicz study responded that they were satisfied with the VHSL's administration of athletics (76.3%), while 79% of participants responded that they were satisfied with the VHSL's administration of athletics in this study (Polakiewicz, 1985).The survey results suggest that satisfaction with the VHSL's administration of athletics has increased when compared to the Polakiewicz study.In regards to the performance of the VHSL, 23.2% of participants from the Polakiewicz study assigned the VHSL a performance grade of 'A--excellent', while only 9% of the survey participants from this current study assigned the VHSL the same grade (Polakiewicz, 1985). In regards to potential issues the VHSL may face over the next five years, the participants identified the following main themes: home-schooled students participating in VHSL athletics and activities, private school participation in VHSL athletics and activities, the financial model of the VHSL, and transgender student policies.

Figure 2: GROBID example summary using reduction method

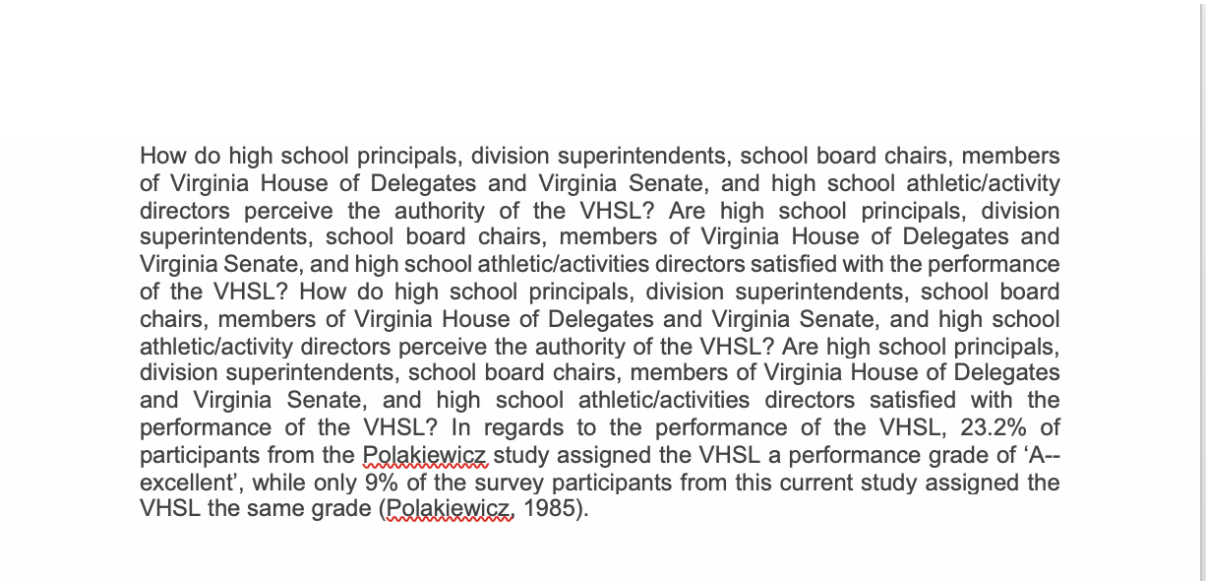


Figure 3: Scienceparse example summary using reduction

SUMMARIZATION: A NEURAL NETWORK APPROACH

Sequence-2-Sequence model

Our main approach is based on transfer learning, i.e., using a model trained on some other dataset for the task of summarizing, and fine-tuning it for our task. Transfer learning allows domains, tasks, and distributions used in training and testing to be different. Transfer learning is mainly used where the training data is outdated or labelling the dataset would be expensive [4]. We train our model using the **BBC dataset and arXiv dataset**.

BBC dataset contains 2225 articles, with a summary for each. The articles are from 5 domains: business, entertainment, politics, sport, and technology. Each article is about 1-2 pages long, with at least 600 words each. The summaries are around 120-140 words long: extractive summaries.

arXiv dataset includes 4,542 articles. The topics which it covers are physics, mathematics, biology, computer science, and economics. Each article contains an abstract which could be used as a reliable abstractive summary for the entire article.

The main model used for this project is the Sequence2Sequence model. In our primary approach, we use Seq2Seq / Attention Enc-Dec RNNs basic models, and based on our dataset

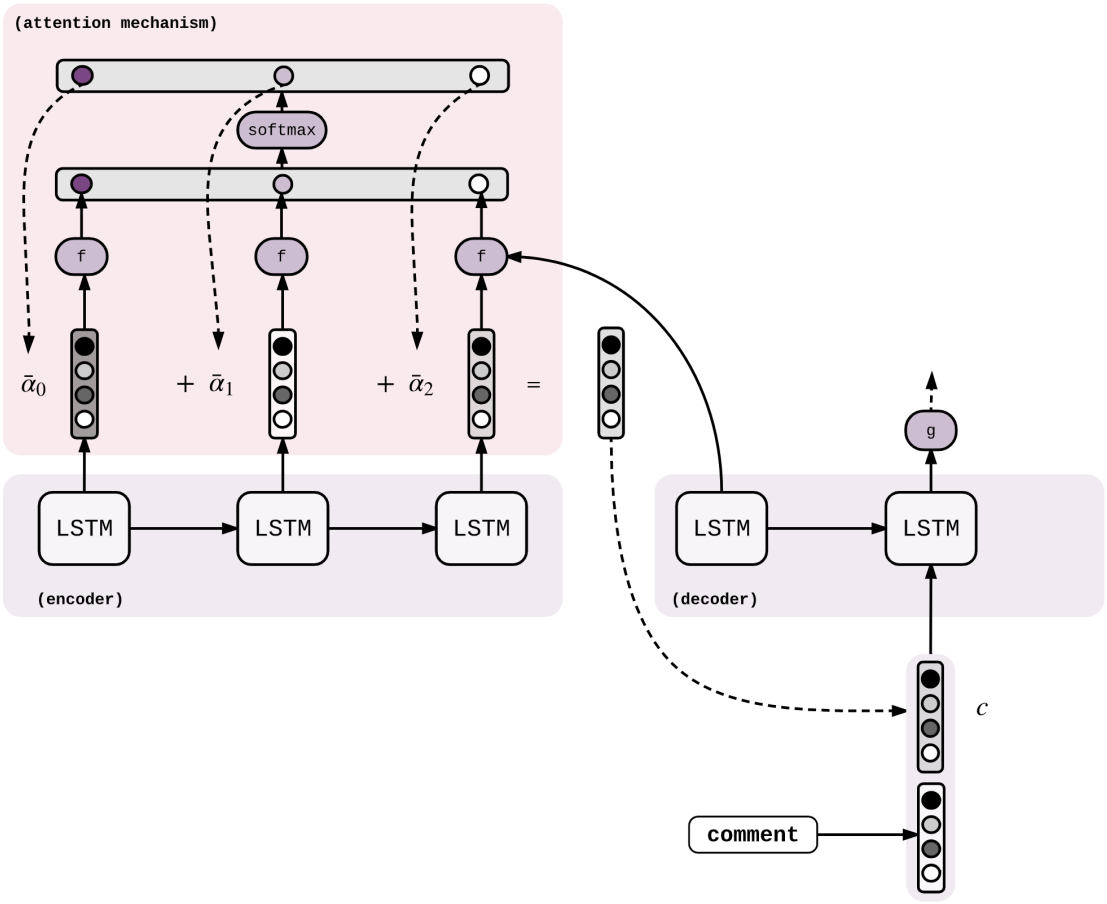


Figure 4: Seq2Seq with Attention Encoder-Decoder RNNs mechanism schema [1]

and the results at each step, improve it. Attention is a mechanism that forces the model to learn to focus (= to attend) on specific parts of the input sequence when decoding, instead of relying only on the hidden vector of the decoder's LSTM (Figure 4). With the purpose of further exploration of models' performance and providing baseline models for evaluation, we have implemented SumBasic (Extractive), Latent Semantic Analysis (Extractive), and 2 graph-based models (Abstractive). These models will serve as comparisons for evaluation. For the first trial and basic Seq2Seq model, the following features have been used for the model:

- Used Glove pre-trained vectors to initialize word embedding,
- Used LSTM cell with stack-bidirectional-directional-RNN,
- Used LSTM BasicDecoder for training, and BeamSearchDecoder for inference.

In our basic implementation, we have trained on dataset from DUC 2003, DUC 2004, and the

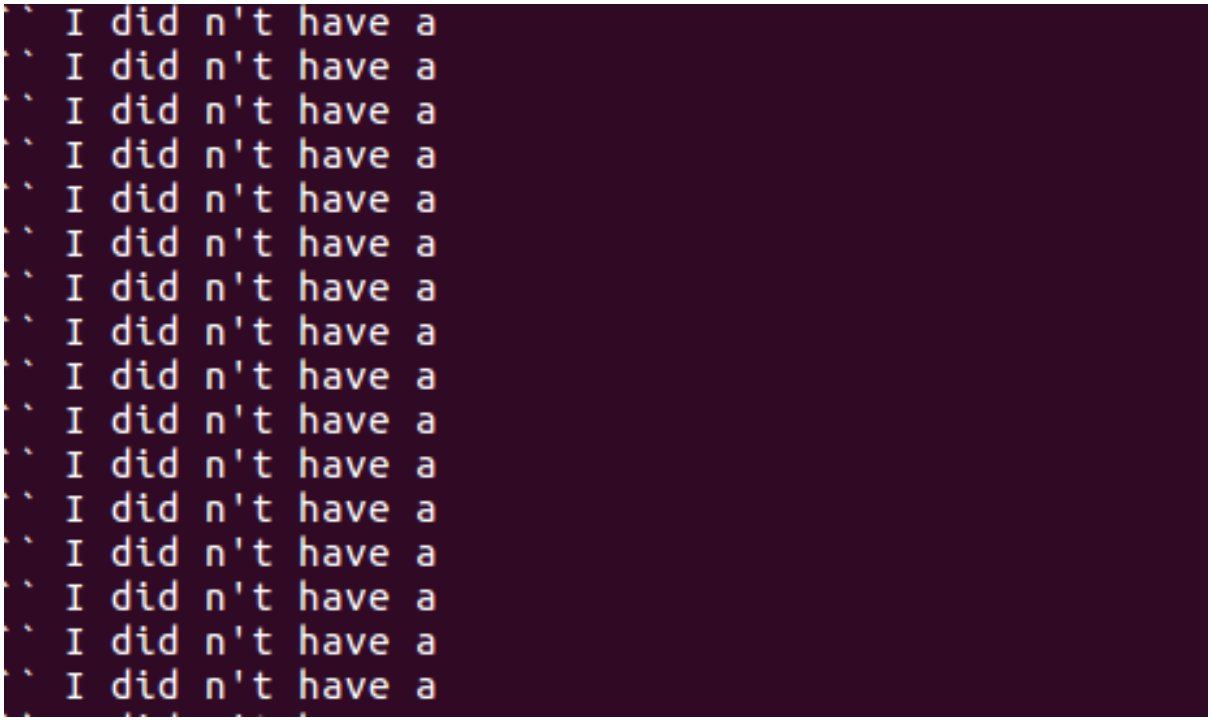


Figure 5: Initial output of Seq2Seq model on BBC dataset

GIGA Dataset. Outputs could be clipped to 75 bytes or EOS using the TensorFlow library [17]. We first ran the basic seq2seq model on the BBC dataset with the following characteristics:

- Size of hidden layers = 400
- Size of word embedding = 200

The dataset was divided into several buckets to create a batch causing less padding. Also, we used a dynamic RNN mechanism along with beam search algorithm. Initially the results were strange (got the same output summary for all the inputs) (Figure 5). The most probable reason for this result is under-fitting. Thus, we tuned the parameters in order to resolve the current issue.

After several attempts and iterations we ran the second round with the following tuned hyper-parameters:

- Optimizer SGD -> Adam
- Number of nodes in each hidden layer : 150 -> 300
- Batch size : 64 -> 32

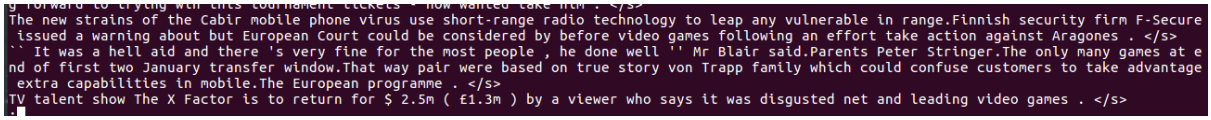


Figure 6: Results from seq2seq model with tuned hyper-parameters and BBC dataset

- Input size : 300 -> 750
- Output size : 50 -> 150

As expected, the results have shown significant improvement compared to the previous model (Figure 6. Though the generated summaries have shown coherency, they were not at all related to the paper. The obvious reason for this issue is the lack of essential vocabulary of ETDs in our training dataset. To resolve this issue, we generated an embedding for word tokenizatiosn from the ETDs vocabulary. For this, we used glove-python to generate a custom glove embedding. In order to improve the training we used the arXiv dataset for an embedding. (arXiv Dataset - 10,140 GROBID-processed arXiv papers with abstracts as the summaries):

Table 1: Embeddings and datasets characteristics

Dataset used	Embeddings
arXiv Dataset	GloVe trained on arXiv dataset
arXiv Dataset	GloVe trained on ETDs dataset

The DUC dataset is divided into several buckets to create a batch causing less padding. The dynamic RNN mechanism used along with the beam search algorithm and the parameters used are as follows:

- Size of hidden layers - 400
- Size of word embedding - 200

The output for Seq2Seq extractive summarization for the DUC dataset with the mentioned parameters is shown in Figure 7.

Pointer Generator Model

The Seq2Seq model has two shortcomings. First, they are liable to reproduce factual details inaccurately. Second, they tend to repeat themselves. On the other hand, a hybrid pointer-generator network can copy words from the source text via pointing, which aids accurate

```
schizophrenia patients in the brains of their own area of their brains
scientists say scientists say scientists say they are linked to <UNK> schizophrenia
yale studies link between schizophrenia and nicotine addiction in study of schizophrenia
study of <UNK> mental disease in new study of <UNK> mental disease
schizophrenia may be most of mental diseases study finds study finds study
<UNK> babies may be more than children born scientists say researchers say
study of schizophrenia of schizophrenia study study says researchers say study shows
schizophrenia of mental illness in mental illness says mental illness may be
nobel prize winner wins albert <UNK> award for his lifetime achievement prize
the heart of schizophrenia but scientists say it is too much to
```

Figure 7: Results from Seq2Seq model and embeddings for DUC dataset

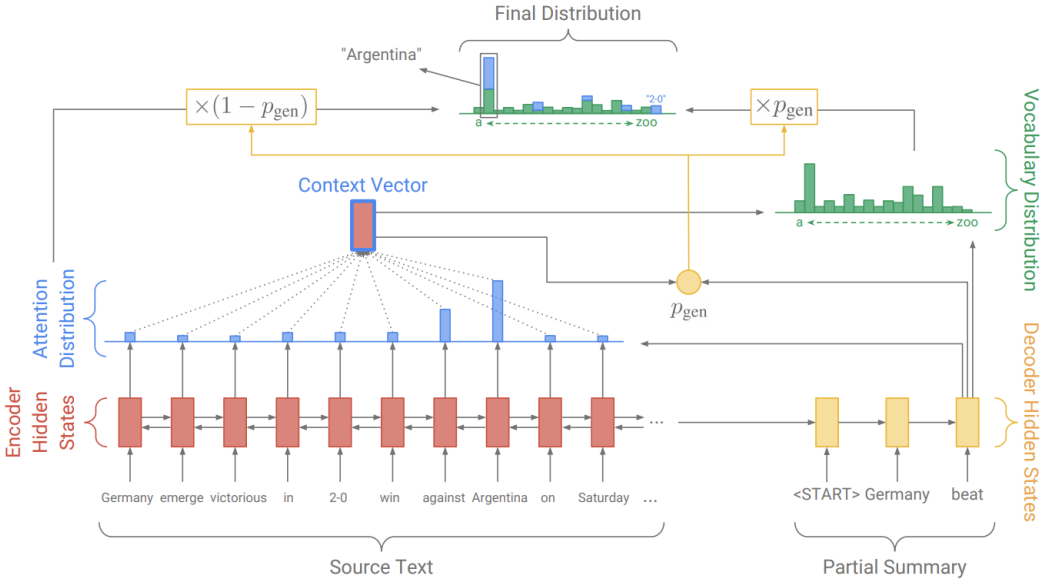


Figure 8: Pointer Generator model architecture [2]

reproduction of information, while retaining the ability to produce novel words through the generator. The pointer generator model uses coverage to keep track of what has been summarized, which discourages repetition [2]. We employed the pointer-generator approach proposed in [18] and tune the parameters for the arXiv and CNN-Daily Mail datasets. Figure 8 shows the pointer-generator architecture. The vocabulary distribution and the attention distribution are weighted and summed to obtain the final distribution, from which the prediction will be made. We tuned the model with following hyper-parameters:

- LR = 0.15
- Adagrad Optimizer
- vocab size = 50000

INFO:tensorflow:REFERENCE SUMMARY: brett __hames__ , 24 , died after coming off isolated pennines road in december . among his final words were : ` i thought i was going to hit the car ' fiancée rebecca gregory , 22 , believes there was another car , as do police . miss gregory has made an emotional appeal for the driver to come forward .

INFO:tensorflow:GENERATED SUMMARY: rebecca gregory , 22 , believes her husband-to-be brett hames , 24 , died after another vehicle forced him off the road and then fled the scene . he died after another vehicle forced him off the road and then fled the scene .

Figure 9: Output of the Pointer Generator summarization on arXiv dataset

INFO:tensorflow:REFERENCE SUMMARY: claims made after it was revealed airbus a320 co-pilot crashed deliberately . today it was discovered andreas __lubitz__ hid an illness from his employers . lufthansa flight training assessments do n't examine personality or lifestyle . lufthansa does not operate a formal vetting process for aspiring pilots .

INFO:tensorflow:GENERATED SUMMARY: alastair rosenschein , now an aviation consultant , made the comments after it was revealed co-pilot andreas lubitz hid an illness from his employers and crashed the plane into a mountain killing 149 people on board .

Figure 10: Output of the Pointer Generator summarization on CNN/Daily Mail dataset

- CNN-Daily Mail and arXiv with 500,000 steps

The arXiv dataset has a collection of 4542 arXiv papers with the following characteristics:

- Full text: 1. Mean(sentence length) = 243; 2. Mean(word length) = 6099
- Summaries: 1. Mean(sentence length) = 7; 2. Mean(word length) = 178

PGNs over-fit on the arXiv dataset due to the small size (4600 articles) (Figure 9). Due to the over-fitting for the arXiv dataset (mainly because of small size), we also used the CNN/Daily Mail dataset in order to improve our model. The CNN pre-trained model has 400 encoding steps and 100 decoding steps (4:1 ratio) and arXiv papers operate on a 40:1 ratio. As a result, a significant improvement was observed in the results (Figure 10)

Hybrid Summarization

Pointer generator models could be concise by performing generation from scratch with an abstractive approach, but they are slow and inaccurate in the encoding of very long documents,

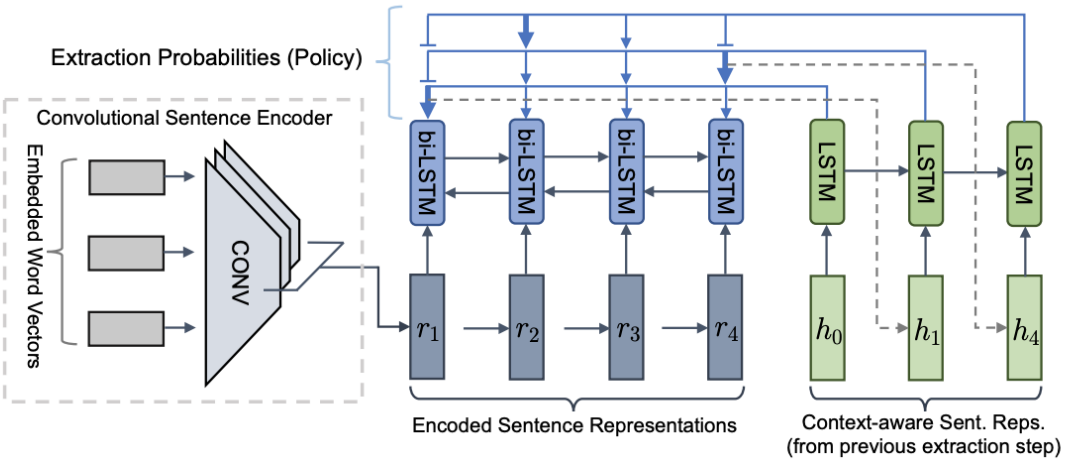


Figure 11: Extractor agent architecture for hybrid summarization model [3]

with the attention model being required to look at all encoded words (in long paragraphs) for decoding each generated summary word (slow, one by one sequentially) [3]. Abstractive models also suffer from redundancy (repetitions), especially when generating a multi-sentence summary. (It took almost 36 hours for training the pointer generator model for CNN/Daily Mail and arXiv).

We employed the model introduced in [3], which is a hybrid extractive-abstractive architecture, with policy-based reinforcement learning. There is an extractor agent to select salient sentences or highlights and an abstractor network to rewrite each of these extracted sentences (Figure 11). Using the maximum likelihood optimization the extractor will be trained to select salient sentences and the abstractor will be trained to generate a shortened summary. Finally, RL is applied to train the full model end-to-end [3]. The reinforcement training of the extractor and its interaction with abstractor is shown in Figure 12.

We applied this model to the CNN / Daily Mail summarization task coupled with fast abstractive summarization with Reinforce-Selected Sentence Rewriting [3]. The results have shown improvement compared to the Seq2Seq model as it has been shown in Figure 13.

A sample original text and the summary generated from it using the hybrid models is shown below:

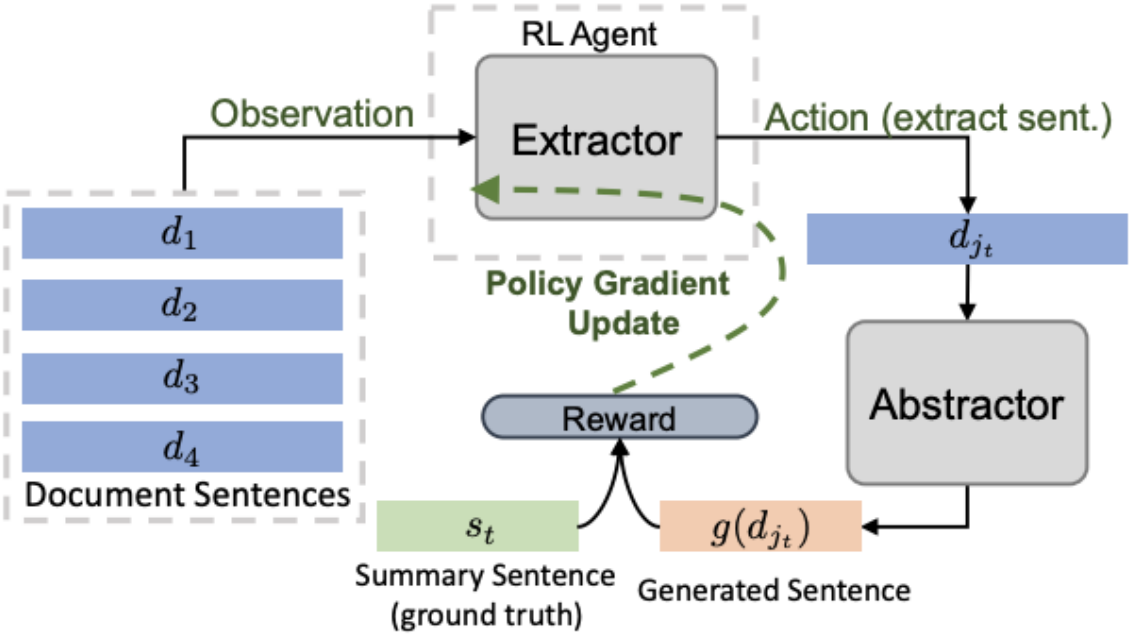
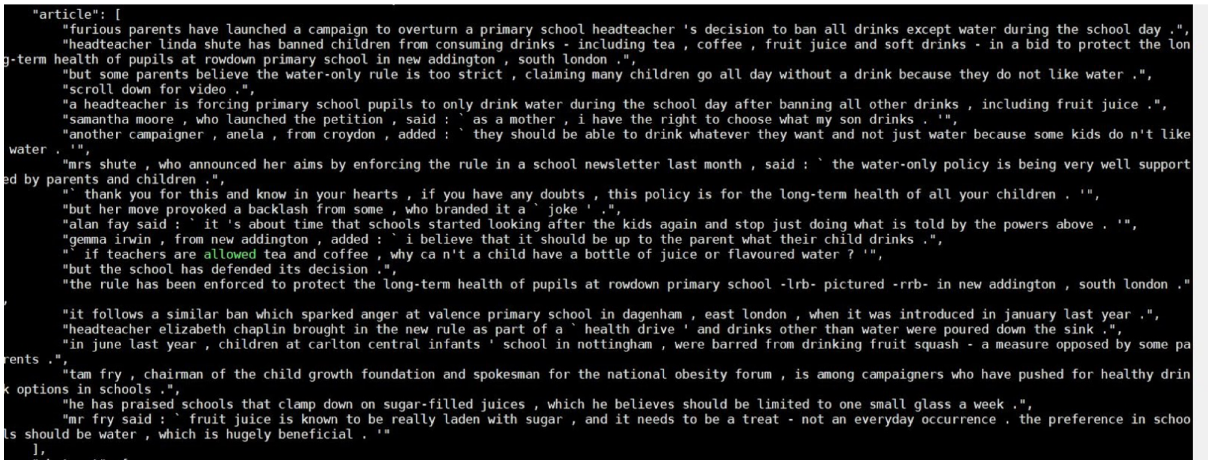


Figure 12: Architecture of reinforcement of the extractor and interaction with abstractor [3]



```
    "article": [
        "furious parents have launched a campaign to overturn a primary school headteacher 's decision to ban all drinks except water during the school day .",
        "headteacher linda shute has banned children from consuming drinks - including tea , coffee , fruit juice and soft drinks - in a bid to protect the lon
g-term health of pupils at rowdown primary school in new addington , south london .",
        "but some parents believe the water-only rule is too strict , claiming many children go all day without a drink because they do not like water .",
        "scroll down for video .",
        "a headteacher is forcing primary school pupils to only drink water during the school day after banning all other drinks , including fruit juice .",
        "samantha moore , who launched the petition , said : ` as a mother , i have the right to choose what my son drinks . '",
        "another campaigner , anela , from croydon , added : ` they should be able to drink whatever they want and not just water because some kids do n't like
 water . '",
        "mrs shute , who announced her aims by enforcing the rule in a school newsletter last month , said : ` the water-only policy is being very well support
ed by parents and children .",
        "` thank you for this and know in your hearts , if you have any doubts , this policy is for the long-term health of all your children . '",
        "but her move provoked a backlash from some , who branded it a ` joke ' .",
        "alan fay said : ` it 's about time that schools started looking after the kids again and stop just doing what is told by the powers above . '",
        "gemma irwin , from new addington , added : ` i believe that it should be up to the parent what their child drinks .",
        "` if teachers are allowed tea and coffee , why ca n't a child have a bottle of juice or flavoured water ? '",
        "but the school has defended its decision .",
        "the rule has been enforced to protect the long-term health of pupils at rowdown primary school -lrb- pictured -rrb- in new addington , south london .",
        "it follows a similar ban which sparked anger at valence primary school in dagenham , east london , when it was introduced in january last year .",
        "headteacher elizabeth chaplin brought in the new rule as part of a ` health drive ' and drinks other than water were poured down the sink .",
        "in june last year , children at carlton central infants ' school in nottingham , were barred from drinking fruit squash - a measure opposed by some pa
rents .",
        "tam fry , chairman of the child growth foundation and spokesman for the national obesity forum , is among campaigners who have pushed for healthy drin
k options in schools .",
        "he has praised schools that clamp down on sugar-filled juices , which he believes should be limited to one small glass a week .",
        "mr fry said : ` fruit juice is known to be really laden with sugar , and it needs to be a treat - not an everyday occurrence . the preference in schoo
ls should be water , which is hugely beneficial . '"
    ],
```

Figure 13: Sample of summary generated from the RL model for CNN/Daily Mail article

Original Chapter

"First and foremost, this dissertation is dedicated to the Lord who has given me the strength and wisdom needed to complete this goal. I put my whole life and trust in His hands at all times. In addition, I would like to dedicate this dissertation to my two best friends, Dan Schmit, and my dog, Brandy. The two of them encouraged me when I was down and were always supportive no matter what crisis I was in at the time. Everyone knows I am not a lover of math, but Dan always told me I could do it and I did it. Working full time and going to classes four nights a week, Dan was always there to listen to my complaints and my celebrations in my accomplishments. Thanks, Dan. Whether late nights or early mornings, my âĂIJfurryâĂİ friend, Brandy, was either beside me wanting to play or just sleeping. Either way she was beside me throughout the entire process. She is now 14 years old and I know part of her is sticking around to make sure I finish. She is the BEST dog anyone could ever hope to own.

Finally, I want to dedicate this dissertation to my parents, Lester and Peggy Reitz.The two of them made sure their children received the best education growing up. Education was very important to them, and I feel I would not be at this stage in my life if they had not planted the seed of setting goals in life and making sure they happenâĂŤno matter what. Thanks, Mom and Dad."

Summary
"the lord has given me the strength and wisdom needed to complete this . put my whole life and trust in his hands at all ' in addition, i would like to dedicate this dissertation to my two best friends, dan schmit, and my dog, she is the best dog anyone could ever own. . the two of them encouraged me when i was down ."

To wrap it, we have summarized the drawbacks and advantages of three models we have used in Table 2.

Table 2: Comparison of the models performance

Model	Dataset	Drawbacks	Advantages
Seq2seq	1)DUC	Generates headlines and not summaries	Not grammatically correct
	2) BBC	Dataset doesn't pertains to task	Coherent summaries
	3) arXiv	Uneven length summaries	Uniform dataset
Pointer Generator	1) CNN/Daily Mail	Slow, inaccurate	Concise summaries
	2) arXiv	redundant summaries	
Hybrid model RL-based	CNN/Daily Mail	Known to be slow and inaccurate for long documents	Coherent sentences, concise summaries

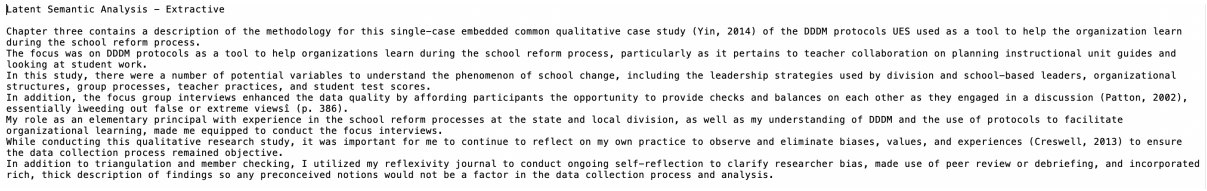


Figure 14: Baseline extractive summary generated from Scienceparse with Latent Semantic Analysis method

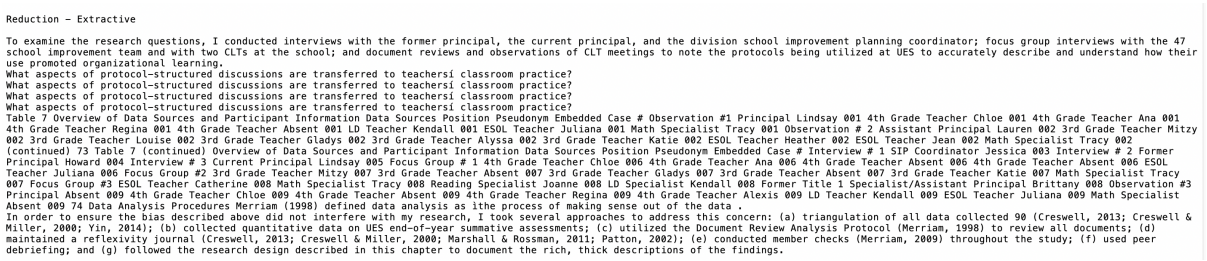


Figure 15: Baseline extractive summary generated from Scienceparse with Reduction method

EVALUATION

Baseline

As we mentioned before, we chose the summaries extracted from Scienceparse and GROBID as the baseline to compare our results against. Both models generate different summaries depending on the hyper-parameters chosen for them. A selection of the summaries generated from Scienceparse and GROBID for a sample chapter is presented in Figures 14, 15, 16, and 17 (for Scienceparse) and Figures 18, 19, 20 and 21 (for GROBID).

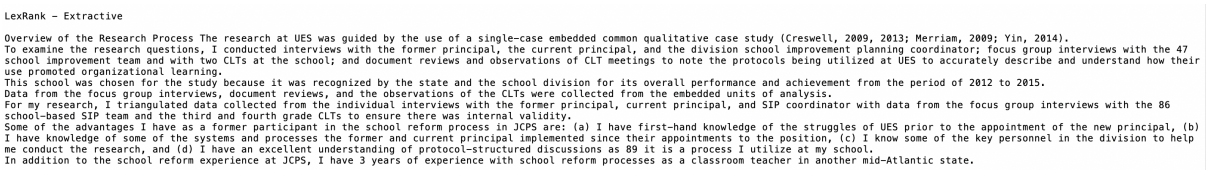


Figure 16: Baseline extractive summary generated from Scienceparse with LexRank method

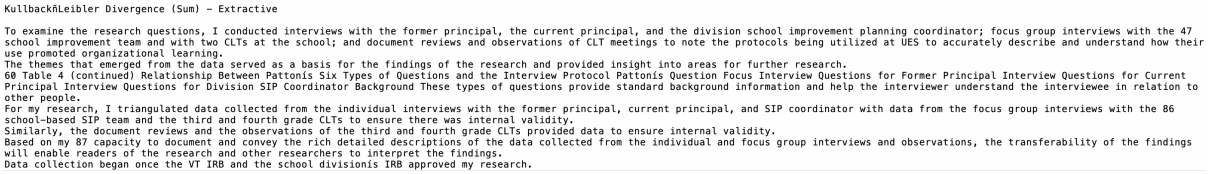


Figure 17: Baseline extractive summary generated from Scienceparse with Kullback-Leibler Divergence method

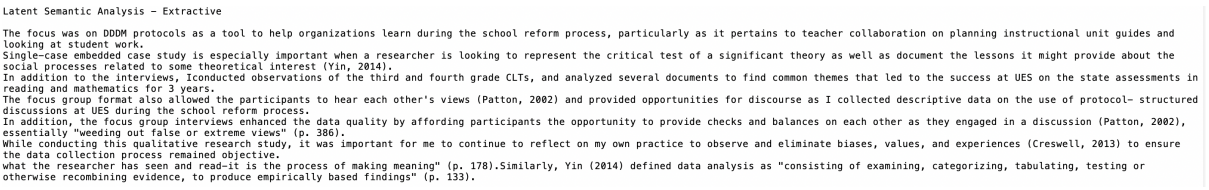


Figure 18: Baseline extractive summary generated from GROBID with Latent Semantic Analysis method

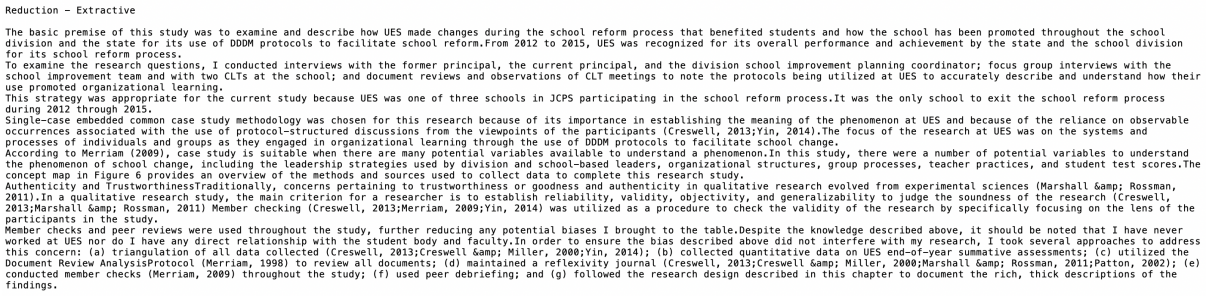


Figure 19: Baseline extractive summary generated from GROBID with reduction method

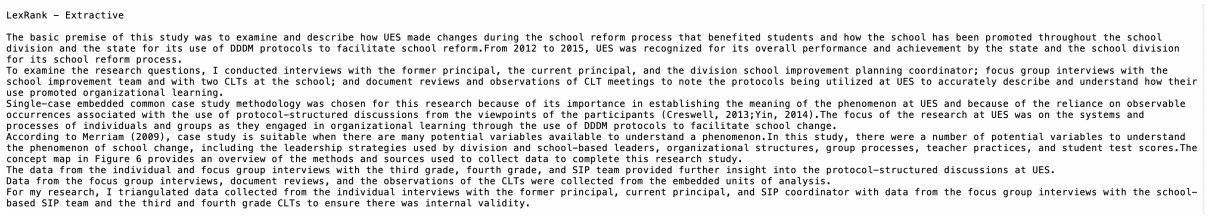


Figure 20: Baseline extractive summary generated from GROBID with LexRank method

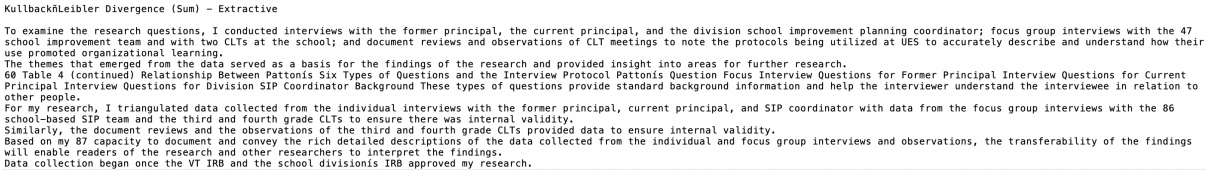


Figure 21: Baseline extractive summary generated from GROBID with Kullback-Leibler Divergence method

ROUGE Score

ROUGE, or Recall-Oriented Understudy for Gisting Evaluation, is a set of metrics and a software package used for evaluating automatic summarization and machine translation software in natural language processing. The three ROUGE scores are pretty low as per the expectations. But the plausible reasons for this can be the different lengths of the original and the generated summary. Moreover, the summarization task is a very subjective one as each person or machine can have their own way of perceiving the underlying concepts, thus, leading to different summaries. The ROUGE 1 score captures the occurrence of 1-grams together, ROUGE 2 is for 2-grams, and ROUGE-SU4 is for the skip-gram and unigram statistics comparison of the two summaries.

Table 3: Average ROUGE score

ROUGE 1	0.1387
ROUGE 2	0.1224
ROUGE-SU4	0.0480

CONCLUSION

Importance of summarization

Given the huge amount of data that surrounds us, this project gave us an opportunity to appreciate the significance of condensed information. In this project, we aimed to take a deep learning approach in order to generate a summary for each chapter of theses and dissertations in an ETD collection. There were three key aspects to this project: Data Preprocessing, Summarization Algorithms, and identification of potential improvements.

The difference in the structure of data and variations opened up a huge need for data pre-processing. We were successfully able to apply existing open source community tools like GROBID and Scienceparse to transform data in a manner that could be easily consumed by summarization algorithms of various kinds. The project also introduced us to various data processing, management, and compression formats used by the community.

Models

Regardless of the modeling technique, our first challenge was choosing a dataset for training which is large enough to train the model properly and at the same time includes a large set of vocabulary from different disciplines to meet the requirements of the ETD dataset. Through evaluating the performance of different models, we have used DUC, BBC, arXiv, and CNN/Daily Mail datasets. Except for the latter (CNN/Daily Mail), all the other datasets did not have a sufficient vocabulary and hindered generation of a coherent summary.

The most basic summarization technique and model we used was the Seq2Seq model. Given the limitations of the model and its implementation, and also the complexity of our problem, the basic model generated summaries that either did not make any sense or were a sequence of repeated sentences. We have improved the model by shifting from the BBC dataset to the arXiv dataset for training purposes and also tuning the model by adjusting the hyper-parameters of the model. The results showed improvement, but still far from expectation. To tackle some of the drawbacks of the Seq2Seq model, we deployed a pointer-generator model designed for text summarization. This approach resulted in fair but not satisfactory results. The best summaries, however, were generated from a hybrid summarization method which combined the essence of both extractive and abstractive summarization using tech-

niques such as policy-based reinforcement learning, pointer networks, and text re-ranking. The method not only generated fluent summaries but also was quick to generate summaries.

Though the generated summaries were far from perfect or matched the coherence in human-written summaries, the project opened us all to a new stream of thought and line of future work. Given the effectiveness of existing models in summarizing short documents, future work could be directed primarily towards addressing the varying length and structure of documents.

USER MANUAL

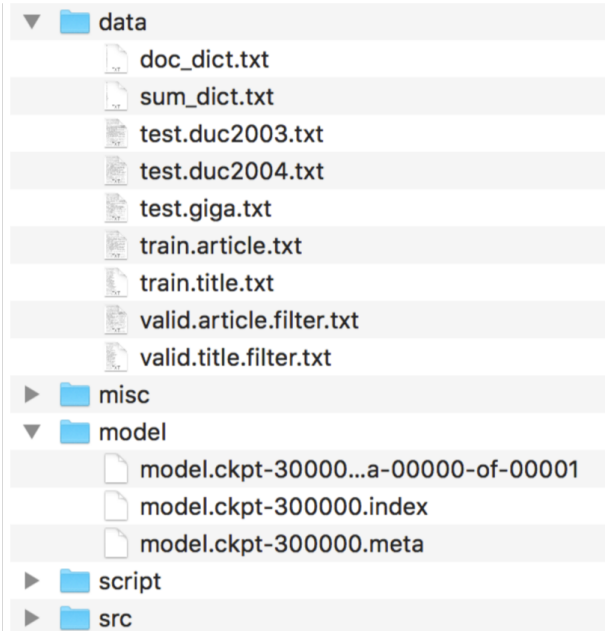
A. Tensorflow Sequence to Sequence

GIT Link : https://github.com/thunlp/TensorFlow-Summarization

1. Download datasets from this link: `https://github.com/harvardnlp/sent-summary`

2. Install TensorFlow 1.1 in the Conda environment

3. Organize data in the following format:



4. Rename the files as following:

```
duc2003/input.txt -> test.duc2003.txt
duc2004/input.txt -> test.duc2004.txt
Giga/input.txt -> test.giga.txt
```

5. Train model with:
   python script/train.py

6. Test model with:
   python script/test.py

B. Pointer Generator Network:

GIT Link : `https://github.com/abisee/pointer-generator`: PGN network in Python

1. Get dataset from the following link: `https://cs.nyu.edu/~kcho/DMQA/`

2. Download Stanford NLP tokenizer: `https://stanfordnlp.github.io/CoreNLP/`

3. Write as following to set CLASSPATH
   export CLASSPATH=/path/to/stanford-corenlp-full-2016-10-31/stanford-corenlp-3.7.0.jar

4. Run as following to get processed bin files: `pythonmake_datafiles.py/path/to/cnn/stories/path/to/DailyMail/stories`

5. Run training as: `pythonrun_summarization.py--mode=train--data_path=/path/to/chunked/train_*--vocab_path=/path/to/vocab--log_root=/path/to/a/log/directory--exp_name=myexperiment---thelogdirectoryisatemporaryfolderwheretheexpe`

6. Run beam search decoding as: `pythonrun_summarization.py--mode=decode--data_path=/path/to/chunked/val_*--vocab_path=/path/to/vocab--log_root=/path/to/a/log/directory--exp_name=myexperiment`

C. Sentence Reinforce

Github (Model): `https://github.com/ChenRocks/fast_abs_rl`

Github (network): https://github.com/ChenRocks/cnn-DailyMail

1. Preprocess Dataset

2. Get CNN/DailyMail dataset from the following link: https://cs.nyu.edu/~kcho/DMQA

3. Download Stanford NLP tokenizer: https://stanfordnlp.github.io/CoreNLP

4. Set CLASSPATH using the following command: export CLASSPATH=/path/to/stanford-corenlp-full-2016-10-31/stanford-corenlp-3.7.0.jar

5. Run the Python script make_datafiles.pytogetJSONfilesandvocab_cntfiles:pythonmake_datafiles.py/path/to/cnn/stories/path/to/DailyMail/stories

6. Fetch the pretrained network from the path:https://drive.google.com/file/d/1to-A8a6my_Eep1B-tbcPVTWtM4T7Yy9F/view

7. To decode summaries from the pretrained model execute the following command from the model directory: pythondecode_full_model.py--path=[path/to/save/decoded/files]--model_dir=[path/to/pretrained]--beam=5--test

DEVELOPER MANUAL

The Seq2Seq model can be found on the following GIT link: `https://github.com/dhruvsharma15/text-summarization-tensorflow`. The explanation of the files is as follows:

- model.py : contains the main model architecture code in Tensorflow.
- prepdata.py : contains code to format data before feeding to the network.
- utils.py : contains utility functions and hyperparameter tuning
- train.py : script to train the network and save the weights
- test.py : script to test the network using the pre-trained weights.

To run this network, just run the scripts in the order mentioned above.

The Pointer Generator Network can be extended from the following link: `https://github.com/abisee/pointer-generator`. The files in the repository are as follows:

- data.py : Generated the data in the required format.
- model.py : stitched various parts of the model like the encoder, decoder, and beam search into a single object.
- runsummarization.py : to run the network and generate results.
- util.py : contains the utility functions to support the network building.

To run this code, just clone the repository and run the scripts.

The Sentence Reinforce Model repository can be cloned from the following link : `https://github.com/ChenRocks/fast_abs_rl`. It contains the same files and steps as discussed in the previous section of User Manual.

SUGGESTIONS FOR FUTURE WORKS

This work certainly could be improved from several perspectives. First, the Seq2Seq model could be evolved to consider more metrics. For example:

Concatenating statements generated for each paragraph of the chapter

- Use the Introduction and Summary chapter to generate the most significant bag of words
- Check if the first / last paragraph of a chapter already summarizes or concludes the chapter
- Each statement receives a weight depending on:
  - Frequency distribution
  - Centrality of words
  - Inclusion of name entity, facts and figures
  - Sentence relative length (too short sentences may not be good for summary)
  - Bushy path of the node (sentence)
  - Sentence Position (Mostly the first sentences and paragraphs are more important and informative)
- Modifying weight / length of one-line summaries depending on the type of chapter such as Introduction or Conclusion

ACKNOWLEDGMENT

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Dr. Fox
Liuqing Li

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APPENDIX

GOLDEN STANDARDS

As a part of the project and in order to generate a human-created baseline, each team were assigned to summarize the chapters of two selected theses and dissertation. While this task was challenging due to the variety of the topics, we succeeded in finishing 10 summaries in total. We include these summaries in this section.

Ashin Marin Thomas

1)Title: **Efficient Community Detection for Large Scale Networks via Sub-sampling**

Chapter 1: Introduction

Systems with distinct interacting entities can be represented using a network, i.e., a group of nodes representing the entities, and links which represent the interactions between pairs of nodes. Graphical models allow mathematical analysis, to aid understanding of complex systems and identification of interesting properties. Variations include heterogeneous networks, where nodes have different types, hyperedges where edges connect more than two nodes, and links that have direction or weight. Of interest here are unweighted, undirected, and homogeneous networks. Adjacency matrices can represent a graph, making some properties like node degree easy to describe mathematically. Graphs can be generated randomly or using a model, such as based on a probability distribution, as in a Poisson random graph. Community detection involves assigning community labels to every node; the goodness of such solutions can be evaluated using various metrics, such as Hamming distance. Label matching can detect if two label assignments are equivalent, i.e., permutations, or what their distance is, which is more clear if suitable label switching is applied. Three community-based models of interest are stochastic block model (SBM), degree corrected block model (DCBM), and popularity adjusted block model (PABM). When there is no ground truth for community labeling, unsupervised methods like clustering can identify groupings that indicate community membership, typically using an error metric to guide the clustering. A popular spectral clustering algorithm using a sub-sampling based method is introduced that out-performs existing spectral clustering methods. Another method considered is the extreme point method which finds the best community assignment for a generalized optimization function. Extreme point algorithm is also extended and experiments undertaken for multiple communities' detection problems. An analysis of spectral properties of the PABM model can guide the

design of a spectral clustering algorithm that is exact for PABM model based graphs.

Chapter 2: Improvement Methods
The chapter proposes different steps to improve Spectral Clustering algorithm but the method of using the sub-sampling method is proved better. The new algorithm splits the original graph into subgraphs by maintaining a certain number of nodes as common in all the subgraphs. After performing spectral clustering over each of these subgraphs, community assignments are stitched together to obtain the community assignment for the entire graph. Experiments are conducted on SBM, DCBM, and real graphs. In all of the simulations, the runtime of the sub-sampling method is much smaller than the actual spectral clustering method, thus giving computational gains. Even within the sub-sampling method, run-times and error rates vary for different sets of parameters. It is deduced that a smaller number of subgraphs implies larger subgraphs, hence smaller error but more runtime. In addition, higher overlap size implies larger subgraphs and therefore smaller error while also increasing runtime because of the larger size of subgraphs.

Chapter 3: Extreme Point with sub-sampling
The extreme point algorithm works well for two communities' scenarios. However, extreme point gets expensive for large networks as complexity increases with network size. So, an extreme point algorithm via sub-sampling is proposed. In the sub-sampling method, the original graph is divided into subgraphs and the extreme point algorithm is applied on sub-graphs. Using the modularity or the optimization function, the best among the subgraphs is determined. These subgraph community assignments are stitched to form the community assignment for the entire graph. The runtime for the sub-sampling based algorithm is much smaller compared to the actual method for any given set of parameters. While the existing extreme point algorithm works for the two-community problem, for multiple communities, the lower dimensional space is not enough to encode the multiple community information. Therefore, a slightly higher dimensional space is designed and assignments are projected into this space. Extreme points detected in this space are good candidates for multiple community detection. An iterative approach is also proposed. It works for a pure information matrix. The issue with this method is that it is computationally very expensive for communities greater than two and even for a small number of nodes, the algorithm is infeasible. The sub-sampling based approach is also applied in this case, which results in bringing down the computation time, but even this saturates for a small number of nodes as it takes an exceptionally high time to run, even on subgraphs.

Chapter 4: Results

An analysis is done and patterns are discovered for the popularity-adjusted block model (PABM) model spectral decomposition. The traditional spectral clustering applicable to a PABM model graph is made by moving to a slightly higher dimensional space where k^2 dimensional space is considered. In this space, k^2 sub-communities are formed by performing a simple distance-based clustering. These k^2 columns need to be transformed to form k communities indicating the communities in the PABM model. For higher numbers of communities, the existence of these k^2 sub-communities is proven, and a manual transformation of these k^2 sub-communities shows that PABM spectral clustering is accurate, given the general function to transform the k^2 sub-communities into k communities. In addition, for the case of two-community PABM model, distance-based clustering in 4-dimensional space leads to 4 sub-communities but there is no function to transform these into two communities. A semi-supervised approach is considered where information about a certain number of nodes from a community is assumed to be known. Using this information, the sub-communities belonging to each community are identified and further community assignment is obtained for the whole graph. This approach has given very high accuracies for PABM model graphs compared to the actual normalized spectral clustering method.

2) Title: **Urban Building Networks' Thermal-Energy Dynamics: Exploring, Mitigating, and Optimizing Inter-Building Effects**

Chapter 1: Introduction

The building sector accounts for nearly 40% of primary energy consumption. Cities, which represent 2% of the earth surface, consume 75% of the world's resources. Efforts to achieve a more sustainable built environment have become increasingly important. Urban morphology – characterized by building density, size, height, orientation, and layout - causes variations in the local environment and microclimates, which are inextricably connected with buildings. Recent research has demonstrated that the interrelationship between buildings within building networks, namely the Inter-Building Effect (IBE), results in inaccuracies of energy consumption predictions. Advancing understanding of urban building networksâĂŹ thermal-energy dynamics can help achieve sustainable energy conservation in the built environment, through optimizing the mutual influences of the IBE in dense urban settings, with numerical and empirical analyses. Early research shows the buildings' energy performance can be significantly impacted by surrounding buildings through mutual reflection

and mutual shading, two essential components of the IBE.

Chapter 2: Overview

Inter-Building Effect (IBE) approaches can enhance energy consumption predictions in dense urban building networks, and continued exploration of complex and dynamic urban microclimates. Manipulating the building envelopes can help disaggregate and quantify the influence of mutual shading and mutual reflection within a network of buildings. Cross-regional case studies of a hypothetical urban building network were established and simulated in the dynamic EnergyPlus environment, followed by two realistic urban context case studies in Perugia, Italy. The findings of energy consumption in the reference building demonstrates that shading has a relatively larger individual impact compared to reflection within the building's microenvironment. In addition, shading contributes to increased heating and lighting loads, while reflection increases cooling energy required for spatially proximal buildings. Tropical cities that have high demand for cooling energy would benefit when reflection is mitigated all year round, while such impact in other cities is closely related to geographical location and climatological context. Understanding the distinct impacts of shading and reflection with separate addressing could lead to optimization of the thermal-energy performance within spatially proximal buildings.

Chapter 3: Phase Change Material

The potential of phase change materials (PCM) technology within an inter-building microenvironment, can be studied regarding reducing the negative impact on energy use, that can result in spatially proximal building networks. A systematic approach is examined to determine the impact of PCM-embedded building envelopes in an inter-building context. This research builds upon and extends previous Inter-Building Effect (IBE) modeling approaches that studied energy predictions in a dense urban building network. A hypothetic building network was modeled in the dynamic EnergyPlus environment under the climatological contexts of four typical cities in the US. The energy consumption of the reference building demonstrated considerable improvement and consistent reductions across simulated contexts. The placement location of PCM-embedded layers was found to be especially important in order to make full use of the thermal storage capacity of PCMs. The results suggest PCM-embedded building envelopes as possible solutions to mitigate negative inter-building influences and improve energy efficiency within urban building networks, especially in temperate cities.

Chapter 4: Biomimicry

Biomimicry is worth exploring to evolve towards achieving a sustained and resilient built environment. Categorizing a number of characteristic applications in the architecture, engineering, and construction (AEC) fields shows that most research effort has been focused on relatively lower levels of organization, such as materials and building (sub-) components. A model to determine optimal urban building network design was introduced and discussed as an example of supporting cross-level assessment. The bioinspired model for urban building development was inspired by intra- and inter- specific competition phenomenon from nature. Designers can understand and take advantage of the interdependencies between urban building infrastructures within a community for net-zero building network design. Going forward, life cycle assessment and industry ecology should also be considered in determining local optimal configurations of individual buildings and building networks. Achieving a high-level synthesis of interactions among the many infrastructure systems and processes will become increasingly important to sustainable building network development and smart growth, as clusters of dense urban settings grow due to rapid urbanization and population migration in the coming decades. The level-of-organization framework elaborated in this study can help deal with challenges by considering the close connections between natural and built environment systems, examining their interdependencies, and seeking solutions at and cross-levels. The discussion of this cross-level organizational comparison clarifies the similarity and strengthens the understanding of the association between the fields of biology and the AEC fields.

Chinmaya Patnayak

1)Title: **Elementary Classroom Organization Delivery Model and Its Effect on Student Achievement David Carl Reitz**

Chapter 1: Introduction
Various elementary school classroom organization models are described, including the self-contained and departmentalized models with their pros and cons. In the self-contained classroom, originally and still widely used except for art, music, and physical education, one generalist teacher conducts all or nearly all the instruction for the class throughout the school day. A highly qualified and competent teacher is permitted to specialize in the teaching of one or a few subjects in the departmentalized model. Historical biases for and against the two models are discussed. The set of four research questions answered through the research work includes determining difference in pass rates and correlation with size of student population and also the school's Title I status. Assessment is done for Virginia fourth-grade students' reading and math class for the year 2009, measured by the Virginia Standards of Learning (VSL) test, to determine the more effective organizational model based on student outcomes and delivery methods.

Chapter 2: Literature Review
The U.S. education system aims to address the diverse needs of students as a strategy to meet the demand for higher student achievement, recently measured with standards-based testing, such as with Virginia Standards of Learning (VSL). Of particular interest is finding empirical evidence for school's organization model guaranteeing success. Researchers have indicated many pros and cons of departmentalized and self-contained classroom settings. According to the peer-reviewed literature of the last 50 years on organizational models, departmentalized models involve not only a significant focus on structure and functionality, but they also involve less sensitivity to individual learning issues. Self-contained classrooms seem to have a higher potential for individual learning, although it might not be feasible for operation on a wide-scale basis or as a model for general curriculum. Though researchers recommend departmentalization at intermediate grades almost exclusively, no conclusive choice has been discovered for structure at the elementary level.

Chapter 3: Methods A method is described to examine the effect of organizational structure on students' achievement as measured by Virginia Standards of Learning (VSL). This "descriptive research" involves research design, four research questions, sample and site

selection, collection and gathering procedures, instrument design, data treatment, management and analysis techniques, and timelines. 19,741 fourth-grade students from 212 K-5 elementary schools in 15 school divisions in Region II Virginia were picked as the sample for the 2009/2010 study; those with special needs or disabilities were excluded since they had an individualized educational plan. After obtaining required permissions from the Institutional Review Board, administrators at participating schools were sent emails with attached surveys. Follow up emails and individualized calls were also made. The responses sent back to the researcher via e-mail were collated and analyzed using the Statistical Package for the Social Sciences (SPSS) version 16.0.

Chapter 4: Results

Results and findings are reported of the effect of organizational structure on fourth-grade students' math and reading achievement as measured by Virginia Standards of Learning (VSL). With a response rate of 63%, the sample space of 134 elementary schools was bifurcated as either self-contained or departmentalized organization models, discarding 40 more samples in which used a combination of the models. Of the 94 schools considered, 53 used the self-contained model and 41 used the departmentalized model; 44% were Title I while 56% were not. Mean school size was 530, with standard deviation 147; the range was 184 to 980. Frequency distributions of sample on categorically measured characteristics of interest were generated and analyzed using Levene's test, Shapiro-Wilk test, and ANOVA, each for reading and math VSL pass rate. The null hypothesis was accepted for each of the four research questions. It was concluded that no significant differences existed in VSL pass rates of students for different classroom organizational models.

Chapter 5: Discussion and Recommendations

Conclusions based on the findings are presented, with discussion on the implications of the findings and recommendations for future studies. Classroom delivery models were not the determinants of students' achievement, as shown by the findings, which were consistent when controlling for school size or Title I status. The subject matter content, and the persistence of both students and teachers to learn, seem to be of greater importance than the organization model. Parallel results by Sauers and Walker regarding classroom delivery models' effect on student's achievements suggest the influence of developments in technology and changing social dynamics. Schools could adopt either model; to increase student achievement, teachers and principals increasingly could focus on the content of subjects being taught and on the personal traits and qualifications of teachers. Future work could

consider the effect, possibly over several years, of other factors such as demographic variables, sample size and sampling all or major subjects.

2)Title:**The Effect of Carbon Monoxide and Steam on Stainless Steel Fiber Reinforced Refractory Castables**

Chapter 1
The study undertaken in the research is introduced and the background is discussed. The goal of the experiment is to examine the effects of carbon monoxide and carbon monoxide/steam mixtures at high pressures and 500 degrees C on stainless steel fiber reinforced castable refractories. The need of the study arises due to recent developments in coal gasification and an investigation is undertaken to predict whether gains in the service life of castables could be achieved by the addition of stainless steel fibers in applications involving carbon monoxide (CO) similar to environments without CO.

Chapter 2
The literature on the detrimental effects of carbon monoxide on refractories is discussed. Reports from as early as 1851 suggested refractory degradation due to carbon deposits, with carbon serving as the catalyst for the reaction. Later studies discussed the effect of temperature and catalysts on the process and defined ranges with the highest activity. Recent studies have investigated the effects of coal gasifier atmospheres and pressure on castable refractories and have attempted to identify the catalyst phase. Several studies also describe the significant strength changes due to steam or addition of stainless steel fibers.

Chapter 3
The experimental procedure included sample preparation, test conditions, apparatus, and safety mechanism. Batches of samples were prepared from calcined kaolin or tubular alumina with commercial calcium aluminate casting grade cement used as the binder. The constituents were cast using aluminum molds. The samples were exposed to test conditions using a temperature and pressure controlled apparatus with safety items. The experimental process was followed, and the samples were inspected for exposure, damage, abrasion resistance, compressive strength and crystallinity using visual and fracture tests, microanalytical techniques, and X ray diffraction.

Chapter 4

The results of the experiments and findings include the effect of gases and prefiring on refractory castables. The effect of gases was evaluated through changes in the visual appearance of the sample's fractured surfaces, specifically for color changes and cracks, and penetration of carbon deposits in the matrix and aggregate grain. Compressive strength variations and abrasion resistance with casting conditions such as water content and temperature were evaluated based on a "strength index" and "abrasion index", respectively. The effect of prefiring was evaluated through exposure to CO/N2/H2O mixture and comparing the results of a subsequent abrasion resistance test. A visual inspection was also made for oxide coating and fiber disintegration. To identify the catalysts for carbon depositions, different fused silica crucibles were exposed to CO and the carbon depositions were determined.

Chapter 5

The results and findings from the experiments conducted include the effect of gas and sample composition and mechanism of degradation. In agreement with the existing literature, exposing 90% alumina castables showed increased damage to the refractory due to addition of steam to CO. The phenomenon is explained through the formation of Boemite. Samples exposed to CO/steam mixtures exhibited a strength increase that competes with the degrading effect of CO, though prefiring showed detrimental strength values. The findings show that most of the damage experienced by all samples in this study was in the concrete matrix. Fe2O3 is the most favorable oxide for catalyzing the carbon depositions. The oxide layer is found to be dependent on historical prefiring treatment, temperature, prefiring atmosphere, and bulk composition of the fibers.

Chapter 6

The experimental work and findings on damage to castables when steam is added to carbon monoxide, and the resistance to the degradation are summarized. The addition of steam to carbon monoxide increases damage to Al2O3, which has lesser resistance to the same, when compared to a 50% alumina castable. In general, the type of fiber has little effect on the CO resistance as long as the oxide coating does not catalyze carbon deposition. The test studies are more severe than actual field conditions. Castables containing stainless steel fibers could be used successfully in CO-containing environments especially in applications such as coal gasifiers.

Dhruv Sharma

1) Title: **Mathematical Models of Immune Responses to Infection Diseases**

Chapter 1

Mathematical biology is a broad field that studies mathematical applications to medicine and other life sciences. This study is centered around the application of mathematics to immunology and virology. While mathematics has been used to enhance medical technology, it has also proven useful in understanding and describing complex interactions within the body. Here the focus is on the application of differential equations to understanding virological and immunological processes. Three projects are described: modeling human immunodeficiency virus (HIV) and human papillomavirus (HPV) coinfection, modeling germinal center formulation and function, and the use of monoclonal antibodies as therapeutics in HIV infection. To understand these efforts, key terminology and concepts must be understood: A virus is a microscopic, infectious agent that inserts itself into biological cells and incorporates its genetic information into the host. Of particular interest are two specific viruses, HIV and HPV. Binding to a target cell alone is not enough for HIV to enter a target cell; HIV must also express a co-receptor, usually CCR5 or CXCR4. HIV infection generally occurs after the exchange of bodily fluids with an infected individual, usually from sexual intercourse, contaminated needles, or poor medical practices. Currently, the primary form of HIV treatment is a combination of antiretroviral therapies (cART). Human papilloma virus (HPV) is a prevalent genital infection that can potentially lead to cervical cancer. The current course of management is to treat HPV-associated lesions as they occur; it is inconclusive if these treatments reduce infectiveness. When a pathogen is introduced into a host organism, the immune response may be classified by how the response is triggered and by its specificity to the invading pathogen. Lymphocytes, a subgroup of white blood cells that are responsible for the adaptive immune response, that include B and T cells, are continually circulated through the lymphatic tissues, lymph nodes, and the spleen, where they may encounter an antigen or pathogen that the body previously encountered. Germinal centers are areas where B cells (which produce antibodies to attack foreign particles) undergo rapid proliferation and are divided into two regions, light and dark zones. Through the processes of somatic hypermutations and affinity maturation, germinal centers create plasma cells; long lived plasma and memory cells provide long-term immunity against pathogens. Antibodies have three main functions in the adaptive immune response: neutralization, opsonization, and complement activation.

Chapter 2

The first immunological models, developed in the 1960s, are stochastic models of immune responses and antibody production. The models studied are systems of ordinary differential equations. Models that describe infections inside an individual are called in-host models. Through in-host modeling, researchers have gained a better understanding of the mechanisms that lead to chronic and acute infections. A basic and widely used model, first used for HIV in-host modeling, contains 3 cell populations: target cells, T; infected cells, I; and virus cells. Some viral models consider a latent phase of infection, which occurs when a host has been infected but the symptoms have not appeared yet. The basic model has also been adapted to include immune responses. Variations of the model include latent infection, acute infection, cellular immune response, and humoral immune response. Two techniques have been used to estimate model parameters: nonlinear regression and Markov chain Monte Carlo simulation.

Chapter 3

Human immunodeficiency virus (HIV)-infected patients are at an increased risk of co-infection with human papilloma virus (HPV), and subsequent malignancies such as oral cancer. To determine the role of HIV-associated immune suppression on HPV persistence and pathogenesis, a mathematical model of HIV/HPV co-infection was developed and used to investigate the mechanisms underlying the modulation of HPV infection and oral cancer by HIV. The model captures known immunological and molecular features such as impaired HPV-specific effector T helper 1 (Th1) cell responses, and enhanced HPV infection due to HIV. The model is used to determine HPV prognosis in the presence of HIV infection, and identify conditions under which HIV infection alters HPV persistence in the oral mucosa. The model predicts that conditions leading to HPV persistence during HIV/HPV co-infection are the permissive immune environment created by HIV and molecular interactions between the two viruses. The model also determines when HPV infection continues to persist in the short run in a co-infected patient undergoing antiretroviral therapy. Lastly, the model predicts that under efficacious antiretroviral treatment HPV infections will decrease in the long run due to the restoration of CD4 T cell levels.

Chapter 4

The ability of the immune system to clear pathogens is limited during chronic virus infections where potent long-lived plasma and memory B-cells are produced only after germinal center B-cells undergo many rounds of somatic hypermutations. The mechanisms of germinal

center B-cell formation were investigated by developing mathematical models for the dynamics of B-cell somatic hypermutations. The models were used to determine how B-cell selection and competition for T follicular helper cells and antigen influences the size and composition of germinal centers in acute and chronic infections. It was predicted that the T follicular helper cells are a limiting resource in driving large numbers of somatic hypermutations. Possible mechanisms are presented that can revert this limitation in the presence of non-mutating and mutating antigens.

Chapter 5
Broadly neutralizing antibodies against HIV are able to act in many different ways in vivo: they can block viral entry, clear plasma virions, or lead to the death of virus-expressing cells. Recently, the 3BNC117 broadly neutralizing antibody has been tested in a phase I clinical trial as a potential alternative treatment of HIV. 3BNC117 is tested to see if it presents with one or a combination of these antiviral effects by developing both a pharmacokinetic model of 3BNC117 dynamics and a viral dynamics model. The models are fit to antibody and HIV RNA measurements from patients given antibody therapy; the conclusion is that 3BNC117 elicits both neutralizing and non-neutralizing effects. It is predicted that antibody binding is delayed and that the combined effects of initial CD4 T cell count, initial HIV levels, and virus production are strong indicators of a good response to 3BNC117 immunotherapy. Also modeled is the effect of antibody boosting on long-term viremia.

2) Title: **Small UAV Trajectory Prediction and Avoidance using Monocular Computer Vision**

Chapter 1
Recently, the private and commercial use of small unmanned aircraft systems (UAS) continues to expand. Low altitude air traffic will become more congested, raising the risk of mid-air collisions that may result in injuries to people or damage to property below. For many years, commercial manned aircraft have used a Traffic Collision Avoidance System (TCAS) to help ensure that aircraft do not collide in flight. The TCAS and similar collision avoidance systems are useful, however, only when every aircraft in the airspace uses the technology. Small UAS typically operate at low altitude where collision threats include general aviation aircraft and other UAS, which may not include collision avoidance equipment. In these scenarios, it is urgent that the small unmanned aircraft be able to sense and avoid these threats. Supporting these systems is work on sensor technologies, computer vision technologies (employing edge

detection, template matching, and optical flow), and aircraft collision avoidance technologies that employ state estimate propagation and collision avoidance methods.

Chapter 2

Recent digital cameras have a human face auto-focus function which is one computer vision technique. It detects a human's face in the image and uses it as a focus point. Also, autonomous driving cars are using computer vision technologies to detect and avoid obstacles in front of them. Likewise, computer vision technologies have become necessary in our life and they will be more popular in the future as well. Both radar and camera technologies can be integrated into small UAS due to low size, weight, and power and cost (SWaP-C). Cameras can be useful sensors for small UAS which cannot afford to use heavy and power hungry sensors. Accordingly, a camera images a small UAS, and computer vision technologies are used to analyze the orientation of a fixed-wing threat aircraft in the camera images. Hunter McClelland, a doctoral candidate in Virginia Tech's Aerospace and Ocean Engineering program, managed flight tests of this research, and Jason Davis, an undergraduate research assistant in the program, developed an edge detection algorithm and a pentagon optimization algorithm. Based on a comparison of computer vision algorithms for threat aircraft detection and feature points extraction, the edge detection algorithm was found to be the most adequate one for this process since the edge detection algorithm has low computation cost which is important for sense and avoid systems; the false alarms can be resolved more easily than in the other algorithms. The computer vision algorithm is applied to the image data from the ground camera system and the algorithm gives the feature points of the threat aircraft successfully.

Chapter 3

A beneficial point of the camera sensor for a sense and avoid technology is that it can see the orientation of the threat aircraft, while other sensors only provide the range and/or bearing. In order to compute the orientation of the threat aircraft, a pose estimation process is needed, which can use the obtained feature points of the threat aircraft. The POSIT algorithm is used for the pose estimation process, and the rotation matrix R BI that maps free vectors from the inertial reference frame to the threat aircraft body frame is obtained as a result of this process. An experiment with a ground camera system is also implemented. The experimental results show that the pose estimation algorithm can compute the orientation of the threat aircraft using only the camera image and the camera orientation when the aircraft is visible in the image.

Chapter 4

Most sensors other than the camera sensor can only provide the range and/or bearing of the threat. Using this position data of the threat, the future trajectory of the threat aircraft can be computed. If a threat aircraft flies along a straight path, it is not hard to predict its future trajectory using only the position data. If the threat aircraft begins to turn, however, then trajectory predictions based solely on position will accrue error; if the error is sufficiently large, it could compromise the prediction algorithm's ability to inform an avoidance decision. The additional information obtained by estimating the threat aircraft orientation enables a more accurate prediction of the threat aircraft trajectory by using the roll angle from the pose estimate and a velocity estimate of the threat aircraft. This prediction method which considers roll angle as well performs better than just a single trajectory position. Specifically, an algorithm is presented for predicting the trajectory of a fixed-wing aircraft using estimates of the aircraft orientation obtained from a monocular camera. The Progress Performance Reports approach also appears to be less sensitive to noise, both in simulation results and in error sensitivity analysis.

Chapter 5

If the trajectory of a threat aircraft can be known earlier and more accurately, the host aircraft can react to the threat aircraft earlier. Therefore, faster and more accurate trajectory prediction of the threat aircraft is important for sense and avoid systems. Accordingly, collision avoidance performances using trajectory predictions generated by the Progress Performance Reports approach and the Pentagon Optimization approach are compared and analyzed. The proposed avoidance algorithm is a combined avoidance algorithm of the worst case avoidance approach and the optimized avoidance approach. Simulation results show that the host aircraft with this avoidance algorithm can avoid the threat aircraft with the least conservative control. Also, the avoidance performance based on the PPR approach and the Pentagon Optimization approach are compared. The PPR approach shows a better prediction performance and less sensitivity to sensor errors, so the PPR approach gives better avoidance performance than the PO approach.

Chapter 6

A trajectory prediction and avoidance algorithm based on computer vision techniques for a small, fixed-wing UAS has been developed. There are a variety of sensors for sense and avoid systems. Camera sensors provide the threat orientation data which cannot be obtained from other sensors. Using computer vision techniques and a pose estimation algorithm, the orientation of the threat aircraft in the image was analyzed and the orientation data

was used to predict the future trajectory of the threat aircraft and avoid the threat aircraft. The vision-based prediction algorithm was designed for a specific use case under restrictive assumptions (e.g., constant speed and altitude) and the results from analysis of flight test data were limited by the richness of the encounter perspectives. Ongoing work aims to refine and improve the algorithm by relaxing these assumptions, obtaining air-to-air imagery and, finally, extending the approach to multi-rotor aircraft. The ultimate aim is to build a complete, real-time system enabling small UAS to see and avoid threats.

Farnaz Khaghani

1) Title: **Promotion and Prevention Fit Are Different but Lead to Equal Performance: Examining Fit Sensitivity and Task Performance Jessica A. Gladfelter**

Introduction

Motivation orientation is part of many models of self-regulation, especially in achievement contexts. Motivation orientation theories are based on the hedonic principle, that individuals tend to move towards pleasure and away from pain. For example, those focused on promotion (e.g., going beyond the required tasks) seek success, while those focused on prevention seek to not fail (e.g., ensure reports are error free). Regulatory focus theory also is based on the hedonic principle, but focuses on success and failure. Regulatory fit (when an individual "feels right" since their regulatory focus aligns with their actions and the methods chosen to achieve a goal) studies generally consider fit sensitivity (as when a product is viewed as a fit or not) and task performance. The purpose of this study is to show that individuals in a state of fit form attitudes and behavioral intentions (i.e., fit sensitivity) that sustain regulatory fit, that regulatory fit also increases task performance (i.e., increases effectiveness), and that this task performance is independent of the fit sensitivity. Attitude development and behavioral intention constitute the fit sensitivity variable. The task studied is making hiring recommendations for police officer applicant profiles, where applicants vary as to risk (high/low) and reward (variable/consistent), and decision accuracy depends on the number of applicants recommended that have an elevated probability of success. The expectation is that those in promotion fit would prefer high risk/variable reward while those in prevention fit would recommend low risk/consistent reward.

Literature review

Regulatory fit, which causes a state of feeling right, happens when an individual's regulatory focus aligns with his/ her goal pursuit strategy. Regulatory fit theory has been validated through different types of dependent variables fit sensitivity and task performance. Most research examines either fit sensitivity or performance, but the current study examines both. Fit sensitivity dependent variables studied in the literature including valuing objects, attitude development, motivation/engagement, behavioral intentions, and behaviors. Studies regarding performance measure when the regulatory fit has been met. It has been shown that regulatory fit states increase performance as compared to non-fit states, where performance has usually been measured through decision accuracy.

Overview

Past regulatory fit research demonstrated that individuals in a promotion-focused state are more inclined to take risks for rewards while individuals in a prevention-focused state avoid risk taking. The current study included both fit sensitivity and task performance dependent variables. A hiring simulation where participants rated the suitability and made hiring recommendation was used to validate regulatory fit.

Methods

143 participants were recruited from a public university in the US southern region; power analysis indicated adequate power would result with 128 participants. Two pilot studies with different sample size (54 participants and then 187 participants) and instructions were conducted. In the study, involving a hiring simulation, participants rated profiles (including 9 attributes) of applicants for a police officer job, and regulatory focus and goal pursuit strategy were manipulated. Fit sensitivity suitability ratings (attitude development and behavioral intention), fit sensitivity of applicants recommended to be hired, decision accuracy, demographics, and time were measured as the dependent variables.

Results

The results of the study showed significant correlations between the dependent variables. Hypotheses 1a and 1b were not supported. Individuals with high-risk/variable-reward were not aligned with the hypothesis expectations. Unlike the hypotheses, prevention/vigilant regulatory fit showed greater preference for risky choices than individuals in a state of promotion/eager regulatory fit. For individuals with low-risk/consistent-reward the interaction between goal pursuit strategy and regulatory focus was not significant but the mean ratings were aligned with the hypotheses. Results have shown individuals with vigilant goal pursuit and prevention focus exhibited greater preference for less risky choices than individuals with eager goal pursuit and prevention focus. The low-risk/consistent-reward applicant profiles mean suitability rating were further analyzed in single profile. However, since the high-risk/variable-reward did not follow the regulatory-fit prediction, no further analyses were conducted. The ordering of mean suitability ratings was consistent with the fit prediction, i.e. suitability ratings in the prevention-vigilant condition means were always greater than the other three condition mean. The results of the tests were also reviewed for hiring recommendation and time to process.

Discussion

The experimental study using a police officer job hiring simulation tested regulatory fit/focus through fit sensitivity and task performance, in a single task. A small or non-existent fit effect has been found which contrasts with the robust phenomenon of regulatory fit in the literature. This can be explained through the more complex task of the case study, as compared to the typical regulatory fit studies. It can also be related to the complexity of decisions the participants were asked to make in this study, compared to the simpler decisions in the typical regulatory fit studies. Regulatory fit is a robust effect but it is also easy to disrupt, meaning that, in a lab condition, the complexity of the task, if high enough, may cause disruption of fit effects.

2) Title: **Normative Orders in the Coast Guard Response to Melting Arctic Ice: Institutional Logics or Anchoring Concepts Haider A. Haider**

Chapter 1

The problem of artic ice diminishing creates concerns and responsibilities for US Coast Guard (USCG). One main consequent challenge is matching objectives to resources and dealing with a shifting operating environment. The problem this study trying to address is how normative orders impact administrative judgement. There are two existing approaches that offer insight into what is occurring in normative orders. First, normative orders as âĂIJinstitutional logicsâĂİ with high level of fidelity and second, âĂIJpragmatist institutionalismâĂİ which said to have a low level of fidelity. The main question of this dissertation is what level of fidelity are normative orders invoked? This dissertation pursues a narrative approach, compared to existing quantitative and ethnographic approaches by interviewing with USCG personnel to identify the normative orders employed in addressing the question of ice breaker capability requirements.

Chapter 2

There are two normative orders that American bureaucracy usually refer to for practice in governance. To better understand these normative orders and how the normative orders impact the decision-making process, it should be turned to the institutional theory to provide a means to explore the existence of multiple normative order. There are two meta-theories for addressing this, which take different perspective with different level of fidelity called the Institutional Logics perspective and Pragmatist Institutionalism. The first one views a stable and ordered set of logics while pragmatist perspective views a normative order as a more contingent experimental set of tools that can be used to explore options.

Chapter 3

To understand the symbolic systems and how normative orders are invoked, in this study the narrative analysis has been employed. For this, the stories that managers told about their action in the environment has been used. The main story line and the opposition that may include some form of sequencing of time, focal actor or actors, an identifiable narrative voice, an evaluative frame of reference, and some form of contextual indicators has been noted and used for the analysis. From all of these elements, evaluative criteria are the one that lead to understanding the normative orders. The data were collected from interviews with HQ of four offices including planning, Resources and Procurement office, Operations Capability Directorate, Operations Policy Directorate, and the Operations Management Directorate. The transcripts of the interviews were then coded and with two sets of hypotheses regarding the normative orders, the analysis has been done. Analysis of the coded information unfolded in two stages. In the first stage, the aim is to prove or disprove the hypothesis posed using a simple frequency count. The second stage of the analysis goes further. While the first stage of the analysis tests the stated hypothesis, the second stage aims to provide an explanation of what is observed.

Chapter 4

The case of Arctic challenge could be divided into three different time periods. Pre-Cold War, during the cold war and after the cold war till present. Different strategies and transitions have happened at each era. The structure of this timeline highlights the importance of the Cold War in shaping thinking before, during and after that period. During the Pre-cold war era there was not an explicit established policy regarding the ice-melting in arctic area but still there were some small exploration about the issue. The cold war era saw an increased concern with the arctic area including security worries because of military transport and deterrence. In the post-cold war era, starting from 1991, more countries were involved in the policies and agreements regarding the usage of arctic area and the USGS was involved more than before. The most significant change in the USGS involvement is the expansion in the responsibilities about the icebreakers fleet that happened after major reductions in both funding and personnel in response to the reinventing government movement in 1997. This challenge creates new sets of mission such as creating a balance between priorities.

Chapter 5

The analysis of narratives mainly structured around two sets of hypotheses. First one is at

the individual level where the purpose is to find the degree of fidelity individuals invoke normative orders. Second set of hypotheses are for identifying the two elements of fidelity, namely clear preference and uniformity, from narratives rather than individuals. For the first set of hypotheses, the results have shown that there is not a non-exclusive preference for a certain normative order and the equal use of normative orders in both individuals and narratives have been observed. For the second set of hypotheses, it was shown that there is a statistically significant indication that the same normative order would not be used to describe both strategy and legitimacy. The Pragmatist Institutionalism perspective may reflect more accurate view of normative orders application. Pragmatist institutionalism represents a more interpretive tradition while the Institutionalism Logics Perspective is more closely aligned with positivist traditions.

Chapter 6

The objective of this dissertation is to recognize how normative orders affect the decision-making and judgement process of USGS about the Arctic melting ice. Understanding how normative orders were invoked in practice would help scholars better understand the conditions of administrative judgement. The idea of fidelity has been used to help distinguish how normative orders are invoked according to two different traditions. There are two sets of implication for this research: implication for scholarship and implication in practice. There is a set of limitations the study faces while it has provided a new avenue. First one is the individual case study that has been used. Second is the limited number of individuals that have been interviewed. These limitations could be addressed in the future works.

John Aromando

Title: **(11838 dissertation) Jefferies dissertation**

Chapter 1

The perceptions of both athletic and school administrators in Virginia regarding the statutes of the Virginia High School League (VHSL) are re-examined in light of the number of student-athletes dramatically increasing to approximately 175,000 since the Polakiewicz dissertation in 1985. As in the Polakiewicz study, the outcome identified and summarized the perceptions of a range of authority figures involved in Virginia education. Perceptions regarding the VHSL are compared and contrasted with the perceptions of those identified in the Polakiewicz study. Since the Polakiewicz study, the VHSL has faced numerous changes and challenges. High school students who participated in extracurricular activities were found likely to be academically successful. Furthermore, socioeconomically disadvantaged students benefited as much, or more than, those students who were not disadvantaged.

Chapter 2

The perception of athletic and school administrators in Virginia is examined. In Virginia, extracurricular activities are presently supervised by a private, non-profit organization named the Virginia High School League (VHSL) which was established in 1913. The Virginia High School League includes public high schools and one private school, classified by student enrollment as 1A through 6A. The current structure of the Executive Committee, which has 31 voting members, has changed since the Polakiewicz dissertation, when there were 25 voting members, involving less representatives from government programs and more school administration. VHSL faced court cases relating to student-athlete eligibility based on residency, undue influence, special education, transfer rules, age rule, and player ejection. VHSL also faced court issues around school district reclassification, Title IX, and liability. Current issues include private school participation, home-schooled students, concussions, and transgender students.

Chapter 3

The Polakiewicz dissertation was utilized as a resource for comparison, including survey questions focused on the overall performance of the Virginia High School League (VHSL), specifically asking about the authority of the VHSL, the performance of the VHSL, and the governance of the VHSL. In addition, an examination of recent legal cases and state legislature involving the VHSL was completed. In late 2016, an updated survey instrument was

distributed to school administration, board members, relevant government figures, and activity/athletic directors. The two phases conducted involved the research and analysis of recent events and case law related to VHSL regulations, and survey research to determine opinions concerning the performance of the VHSL.

Chapter 4

A small percent of the 419 survey responses were from legislators while school administration (e.g., principals, athletic directors, superintendents, school board chairs) made up the majority. A strong majority responded favorably to the Virginia High School League (VHSL) imposing periods of probation on participants. A strong majority also believed that the VHSL is doing a good job; 23% gave a grade of A, 47% B, and 21% C. Most agreed that penalties imposed by the VHSL were appropriate. Half of participants had received 1-5 complaints against VHSL, and 21% received none. Those surveyed responded favorable to an impartial fact-finding panel hearing appeals. A majority believed the VHSL should do more to educate parents, regulate officials/referees, and provide athletics and activities for students. A majority believed the VHSL does an adequate job on concussion and sportsmanship education. Common themes of concern involved reclassification, home schooling, and communication.

Chapter 5

Results suggested that the Virginia High School League (VHSL) is supported in prohibiting individuals and imposing penalties. Viewed favorably are their concussion and sportsmanship education, safety guidelines, and overall performance. Results suggested that the VHSL change the way they hear appeals, undertake parental education, and oversee game officials. Results suggested that the VHSL should consider making a coaching education class an annual requirement, monitoring homeschooling legislation, providing athletics and activities for students, making a clear classification model, and enhancing the VHSL website. High school athletic/activity directors were included, a group not in the Polakiewicz study. Results showed more favorable views toward the VHSL imposing probation and an increase in satisfaction with the VHSL when compared to the Polakiewicz study. Future research might focus on the financial model of VHSL, independent panel use in hearing appeals, and the alignment of member schools.

2) Title : **(17454 theses) Salinas thesis**

Chapter 1 Introduction

Mood disorders (like depression), anxiety, mental illness, and other psychological concerns can be challenging for children. Many individuals believe that internalized symptoms will dissipate on their own. Often, however, when symptoms occur in a child, a parent or guardian must act on seeking out help. Parents and guardians also impact the childâĂŹs desire to seek help through their disposition. A combination of social and cultural practices of a family play a role in whether help will be sought. Factors like familism, acculturation (and its opposite enculturation), play a role where a balance of acculturation and enculturation is ideal. Disclosure and secrecy play an important role in child help-seeking. Family factors are sought that play a role in predicting the disclosure-related decisions made by children from differing cultural groups. Hypotheses concern caregiver parenting styles, caregiver attitudes toward help-seeking and mental illness, and cultural factors among international families.

Chapter 2 Methods

Participants included 40 pairs of a female caregiver with a child between the ages of 9 and 12. Two groups were formed: families who were born in the U.S. and families where a caregiver was born outside the U.S. Information was collected on perspectives towards mental health and psychological help, cultural background and values, and the child's competencies and problems. Appointments took place in a private office space with the caregiver and child separated to complete their respective tasks. Preliminary statistics were calculated for the central thesis question separated by cultural group. These statistics were assessed to determine potential covariates and control variables. Discriminant Function Analysis (DFA) was used to conduct multivariate analysis of variance tests of the three hypotheses.

Chapter 3 Results

Domestic caregivers reported lower levels of over-protectiveness than did international caregivers. Additionally, domestic caregivers reported more favorable views toward help-seeking and less stigma. The overall Chi-square test for parenting styles in the domestic sample and international sample was not significant. For the second hypothesis about children's most likely decision related to disclosure of mental health concerns depending on parental mental health attitudes, the overall Chi square tests were non-significant for both the domestic and international group. For the third hypothesis about whether the likely decision related to disclosure of mental health concerns among children of international families would differ significantly based on their caregivers' cultural background, the overall Chi-square test for the anxiety vignette was significant, but for the depression vignette was not.

Chapter 4 Discussion

The study, which included open-ended instructions and newly developed techniques not yet validated, expanded on the existing literature, analyzing various elements that have been previously implicated. Despite research stating otherwise, results did not show a link between parenting style and children's disclosure and/or secrecy. No statistical significance was found between caregiver attitudes toward mental health and children's likely decision on disclosure; studying disclosure was a novel contribution. Evidence showed cultural minorities are less inclined toward seeking professional mental help. Findings indicate that children's preferred decision to speak up depend on the attitudes held by their parents. Evidence was found about anxiety being dependent on cultural factors for disclosure made by children of international families. Children of international families were more likely to mask their concerns when caregivers demonstrated low levels of acculturation. Future studies should investigate the pattern observed of discrepancy related to anxiety versus depression, children struggling with clinical concerns, and specific sources of internalizing.