Thesis Notes

## ~~Applications~~

~~Potential areas of interest for this system can be people with dementia (PWD) and using this as a way to track whether someone’s speech is suggesting they are showing warning signs in their speech and might require aid, or for monitoring their state over long periods and tracking potential early warning signs and if they arise. For PWD these can be~~

~~Currently this system would use a transcript approach, but ultimately would aim to record speech and translate it directly.~~

~~PauseCode looks at the micro scale by analysing pauses and their meaning to a conversation, entropy is used to assign a value to the different speakers for identification.~~

~~Dementia has a range of identifying markers that can be located through looking at pauses or shorter conversational turns, is my role in this project to find ways to symbolize more conversational patterns?~~

## ~~Notes from Andrew:~~

1. ~~Probably 5-8 critical pauses (~64 have been characterized, but no relevant, maybe 3-10 instead)~~
2. ~~Entropy will be determined for two cases. Case A: In group. Case B: Out of group.~~
3. ~~Zipf-Mandelbrot-Zi law is for modelling natural language.~~
4. **~~Minimal set of symbols for dialogue and monologue~~** ~~straddling the line between unnecessarily complex symbol sets and useless symbol sets that don’t possess enough nuance.~~
5. ~~Will need to collect pause data from CalPy to develop histograms to find what a distribution of pause lengths looks like.~~
6. ~~Will need to feed Audio of conversations into CalPy to do this and~~ **~~find the pauses~~** ~~and~~ **~~collect pause data~~**
7. ~~I could try clustering pauses to see where they fall as well.~~
8. ~~Analysis of complexity from symbol sets to determine a good spot between too small to be useful, and too complex to be fully utilized.~~
9. ~~Analysis of symbol storage requirements and runtime performance as symbol complexity increases. Using that as part of analysing conversation content to determine symbol requirements?~~
10. ~~Essential Characteristics behind pauses?~~
11. ~~Likely pause and key pause events~~
12. ~~Types of pauses, what they mean~~
13. **~~Most meaningful pauses~~**
14. ~~Impossible or meaningless pauses (i.e. don’t add value, they can be lumped together, theyre redundant).~~
15. ~~Further symbols after pauses could be utterance lengths, pitch changes, tonal shifts. Determining processing levels for symbols. End up with a vector of entropy.~~
16. **~~Pause symbols~~**
17. ~~Pause length between utterances~~
18. ~~Pause Type (will this be necessary)?~~

## Goals:

**Overarching place in the field:** **Florence Project** - Aiding communication through technology. Analysing, tracking of recurrent patterns in conversation of PWD.

**Overarching project: Andrew’s work** - Detecting change in conversation or detecting when a meaningful pause has been made that shows conversation ending that is context specific (i.e. based on the person speaking), trying to aid in establishing early warning signs of early onset dementia or aiding in communicating with

**My project goals:** Use symbols to detect changes in speech in relation to pausing through text currently? What about speech? Or possibly a transcript? We want speech to analyse but is that too difficult, should we use a transcript first? Implement Andrews papers.

Related keywords: Dementia, Conversation, Recurrent conversational problems, Analysis and identification of this through text (Potentially transcript), Communication breakdown, symbols?, backchanneling, communication pauses, entropy in language

## Entropy Calculation

**Determining the Number of Samples Requires to Estimate Entropy in Natural Sequences** [[1](#Bac18)]

**Source:** <https://arxiv.org/pdf/1805.08929.pdf>

**Summary:** Given only a short sample size to compute entropy on a natural language, this provides a benchmark for reliable entropy calculation.

**Relevance:** This provides benchmarks for the minimum number of symbols the data should have to make correct conclusions about the entropy of those samples when analysing it.

**Fast Entropy Estimation for Natural Sequences** [[2](#Bac181)]

**Source:** <https://arxiv.org/abs/1805.06630>

**Summary:** Method for estimating the Entropy of a given message requiring significantly less samples than the alphabet size (e.g. not relying on slow histogram approaches) with minimal error.

**Relevance:** In trying to determine a speaker from a group (and whether they are departing from the norm), it’s important to be able to determine the entropy for given messages when only small amounts of samples are present. It’s this entropy calculation that allows for analysis and quantification of a person’s speech.

**Simple entropy estimator for small datasets** [[3](#Mon12)]

**Summary:** Given a small data set, it is not necessary to use a histogram approach to estimate entropy; it can be estimated through “character coincidences” needing only a small number of samples (relative to the alphabet size).

**Relevance:** This is important for developing a quick estimate of entropy calculation for a given sample set and provides the mathematical foundation outlined in the Fast Entropy paper above.

**Shannon Entropy Paper**

**Summary:** Defines rules for analysing and measuring entropy of language using statistics.

**Relevance:** Sets the foundation of research for all Information Theory texts.

## Conversational Analysis

**PauseCode: Computational Conversation Timing Analysis**

**Summary:** Looks at the important role pauses play in speech and the information they provide through their use.

**Relevance:** When determining what symbols to look for in speech, this paper outlines the impact a pause can have on illuminating a speaker’s interest, engagement or potential trouble in the conversation. Pause lengths that are too long can show the speaker is not engaged or having trouble following through the conversation (e.g. spending significant time remembering words). By using software to document and highlight meaningful pauses, tracking signs of trouble can become an automatic process.

**Conceptual Recurrence Plots: Revealing Patterns in Human Discourse** [[4](#Ang12)]

**Source:** <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5887327&isnumber=6180049&tag=1>

**Summary:** Visualises conversations by colour coding recurrent patterns on a semantic/conceptual level rather than a term based level (i.e. the same idea versus the same word). Salton is used to build the underlying semantic model.

**Relevance:** This helps with identifying when certain topics are being rediscussed continuously because of a breakdown in conversational ability for PWD. Reliance on a lot of back-channelling can be seen, as well as how deep a conversation is versus when not a lot of progress is being made to establish meaningful conversation (e.g. changing topics). Meaningful conversation is important for PWD and using visualisation techniques to track what does and doesn’t work is important. Visualisation can be quantified by the shading, frequency and the number of places that recurrences take place in the conversation.

**Human Communication, Quantifying Multi-participant recurrence (MPR) metrics** <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6161608>

Summary:

Relevance:

## Dementia Analysis

**Visualising dementia conversations** – Daniel, Janet, Helen: <https://www.cambridge.org/core/services/aop-cambridge-core/content/view/94641FE0FDBC9F84F38C28B5480F2E13/S0144686X13000640a.pdf/visualising_conversations_between_care_home_staff_and_residents_with_dementia.pdf>

**Summary:** Using Discursis to analyse the conversational patterns that emerge between PWD's and their carers.

**Relevance:** This provides documentation of further symbols to look for when estimating entropy and trying to pinpoint the presence of dementia through text or speech, and ways of helping those conversations through specific prompts.

**Automated Examination of Dementia Conversation** – Daniel, Janet, Helen: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0144327>

Summary:

Relevance:

**Trouble and Repair:** Helen Chenery, Janet Wiles

**Source:** <https://www.tandfonline.com/doi/pdf/10.1080/026870399402181>

**Summary:** Analysis of common Trouble Indicating Behaviours (TIB's) of patients with Senile Dementia of the Alzheimer's type (SDAT) and the effectiveness of using known repair types to aid in communication with their carer’s.

**Relevance:** Identifying a structured list of typical breakdowns for People with Dementia (PWD) in communication. This aims to aid in potential new paths of treatment or aid by identifying what patterns of speech work with PWD and what doesn’t. This can also be used to help with identifying valuable symbols or patterns in speech to look for.

PWD/SDAT (Senile dementia of the Alzheimer's type) conversational traits:

1. Shorter conversational turns,
2. called or regular prompts from the interviewer,
3. increased amount of reference errors,
4. missing elements in conversational turns of SDAT subjects,
5. more topic initiation and unexpected topic shifts (due to failure to continue and repetition of an idea.
6. Incoherent, meaningless or vague
7. Trouble Indicating Behaviours:
   1. Lack of uptake/Lack of continuation
   2. Reprise/Minimal dysfluency
   3. Pauses
   4. Request for repetition
   5. Not requesting specific information
   6. No hypothesis formation

**An analysis of trouble and repair in the natural conversations of people with dementia of the Alzheimer's type**

<https://www-tandfonline-com.ezproxy.library.uq.edu.au/doi/pdf/10.1080/026870399402181?needAccess=true>

**Signals and Systems: MIT Lectures**

<https://www.youtube.com/watch?v=-FHm2pQmiSM>

**Summary:** Looking at complex systems in abstract terms to simplify to just input and output  
**Relevance:** is this just background research or can I reference it as lit review

It abstracts away unnecessary elements of a problem. Looks at signals as input/output and the relationships between them in terms of a function for studying phenomena. Signal is an x-dimensional function (of time or possibly not, just need a function to model our movement with independent and dependent variables), can be multidimensional.

For our research we are looking at something that is both continuous time (CT) signal and a discrete time (DT) signal, CT in the actual verbal input from the speaker, but will be DT in the computational aspect of recording and analysing. How to convert from CT to DT and what do we need to capture and what is the cost for storing everything? What’s the slowest sample rate we can have?

Functions behave as they always will, they’re bound to their output from their input, but signals and systems is looking at manipulating how their information is sent back to us in a new order essentially. So if it’s f(2x) we are getting every second f(x) point, thereby squishing the data down to get half as much. F(-x) will give us a flipped version of what we are looking at, sending the information backwards, reverse order. F(x-250) is making the timeline wait longer to get to the 250 point, you are pushing it back to happen later (further into the x axis). This is essentially looking at how to manipulate functions given only the input and the output to change, how can we modify the data we’re getting back.

Are we actually just trying to see how to approximate a new function from a given function?

**Discursis**: Discursis would be used to potentially map out the pauses in communication

<http://discursis.com/index.php/news-and-research/>

**CalPy** - Software used to aid in this <https://github.com/YvonneYYu/calpy>