

Adaptation of IDPT system based on patient-authored text data using NLP

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- Background (About Project, Mental Health, IDPT, Problems)
- Motivation (Using NLP technique to adapt IDPT interventions)
- Methods (Data collection, Preprocessing, Embedding, Comparison)
- Results
- Discussions/ Challenges
- Future works

Background

- INTROducing Mental health through Adaptive Technology (INTROMAT).
- Our aim is to improve public mental health with Adaptive technologies (ICT) and psychological treatments.

INTROMAT

ATTENSI

MODUMBADit
- en kilde til liv

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Mental health statistics

1/4 people in the world will be affected by mental or neurological disorders at some point in their lives. 450 million people are suffering from mental or neurological disorders around the world. [1]

Based on EU Green Papers 1/4 citizens is affected by mental health problems at some point during their lives and has often led to suicide [2, 3].

About half of the Norwegian population may have experience of mental health problems during their life, and about one-third during one year [4].

According to WHO [1], Less than half of those affected in the world receive such procedures due to long waiting lists, high treatment costs and social stigma [5]. Depression can lead to suicide, and close to 800 000 people die due to suicide every year [1].

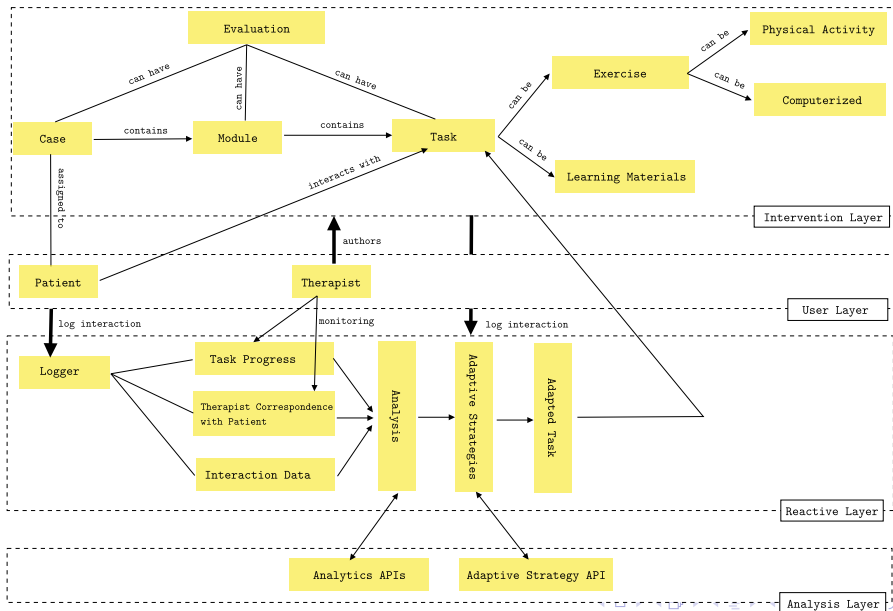
Important question

How can be address the issues of growing mental health disorder and provide healthcare facilities to far-reaching population?

Possible solution: IDPT?

- Internet Delivered Psychological Treatments (IDPT)
- Developed in 1960s [6] and most commonly practiced and extensively researched forms of psychotherapy [7].
- Any form of treatments/therapy delivered through Internet.
- Usually involves web-applications, mobile based, Augmented/Virtual reality environment, or desktop applications.

Main components of an adaptive IDPT system



Example - ADHD case in INTROMAT

- **Case:** ADHD
- **Modules:** 7 Modules
 - 1 Start - introduction, symptom description and goal setting
 - 2 Breathe - inattention and breathing exercises
 - 3 Stop - awareness and stop exercise
 - 4 Emotions - description and characteristics of the basic emotions, emotion regulation techniques
 - 5 Problem solving - identifying problematic behavior and changing this
 - 6 Planning and organization - using a calendar to plan, to do lists, dividing tasks into subtasks, energy budgeting
 - 7 Acceptance - self acceptance and self care exercises
- **Tasks:**
 - 1 Reading/Listening/Watching
 - 2 Setting personal goal
 - 3 Self assessment through psychometric test (ASRS V1.1)
 - 4 Feedback after exercise.

Problems with IDPT system

90% of the IDPT systems are tunnel-based [8]

Too much content without much flexibility [9]

Lack of personalization [10]

Lack of therapists feedback [11]

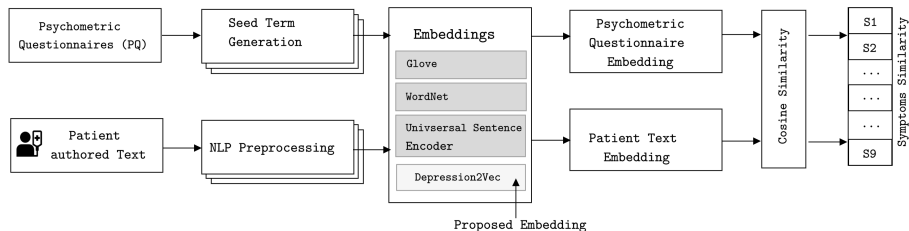
Consequence

Low user adherence and higher dropouts

Objectives of this study

- ① We aim to adapt IDPT system by extracting depression symptoms from patient-authored text using Natural Language Processing (NLP) techniques.
- ② The main motivation to adapt IDPT system is to provide personalized treatment experience in order to increase user adherence and reduce dropouts.

Method - overall workflow



Psychometric Questionnaire - PHQ9

Over the last 2 weeks, how often have you been bothered by any of the following problems?

(Use a check mark to indicate your answer)

	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself – or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or hurting yourself in some way	0	1	2	3

FOR OFFICE CODING _____ + _____ + _____ + _____

Initially handpicked seed terms

ID	PHQ-9 symptoms	Extracted Lexicons
S1	Little interest or pleasure in doing things	[interest, interested]
S2	Feeling down, depressed, or hopeless	[feeling, depressed, hopeless]
S3	Trouble falling or staying asleep, or sleeping too much	[sleep, asleep]
S4	Feeling tired or having little energy	[tired, energy]
S5	Poor appetite or overeating	[appetite, overeating]
S6	Feeling bad about yourself or that you are a failure or have let yourself or your family down	[failure, family]
S7	Trouble concentrating on things, such as reading the newspaper or watching television	[concentration, reading, watching]
S8	Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	[moving, speaking, restless]
S9	Thoughts that you would be better off dead, or of hurting yourself	[dead, hurt, suicide]

Seed term generation

- For each symptom terms in each symptoms in PHQ-9 questionnaire, we used *WordNet* to find synonyms.
- Then, for each synonym, we find the associated hypernyms, hyponyms, and antonyms.
- Our empirical results showed the top five words were highly correlated with the original symptom term, so we chose the top five words for each symptom.
- Similarly, for method using (*GloVe*), we used only those words with a higher than 80% similarity.

- 1 Started with *Universal Sentence Encoder* (USE), publicly distributed by Tensorflow-hub.
- 2 *WordNet* is a machine-readable lexical database for English developed at Princeton University.
- 3 *Global Vector Representation* (GloVe) is an unsupervised learning algorithm for getting vector representation for words.

Patient authored text embedding

- ① Computerized exercises written by patients' during intervention.
- ② We pr-processed these texts,
 - convert the test sentence into UTF-8 format to maintain encoding consistency,
 - transform all letters into lower case,
 - remove any extra spaces around the sentences,
 - remove symbols (#, +, -, *, =, http, https) present in the sentence,
 - replace a short form of words with full formation, e.g., *won't* is replaced by *will not*, *can't* by *cannot* and so on.
- ③ And fed to same embedders (USE, WordNet, and GloVe).

Similarity computation - cosine similarity

Given two vectors \mathbf{t} , \mathbf{e} , where \mathbf{t} representing vectors encoded from test sentence (patient-authored text) and \mathbf{e} any particular PHQ-9 symptom, we use cosine similarity to compare these two vectors. The similarity measure is defined as follows:

$$\cos(\mathbf{t}, \mathbf{e}) = \frac{\mathbf{t} \cdot \mathbf{e}}{\|\mathbf{t}\| \|\mathbf{e}\|} = \frac{\sum_{i=1}^n \mathbf{t}_i \mathbf{e}_i}{\sqrt{\sum_{i=1}^n (\mathbf{t}_i)^2} \sqrt{\sum_{i=1}^n (\mathbf{e}_i)^2}} \quad (1)$$

For all the cases, WordNet performed better than USE, GloVe. However, we realized WordNet resulted in several false positive.

- The contextual knowledge (large corpus pre-trained word2vec models) are built using public sentiment lexicons (*Wikipedia texts*), and sentiment knowledge (*Twitter data*) is derived by using the word sense in the context and co-occurrence frequency.
- The lexicon-based method shows promising results due to the existence of a high-quality emotional lexicon.
- A fine-grained emotional lexicon embedding can improve the accuracy in the classification of various symptoms.
- Hence, we started creating our own fine-grained embedding. We refer it as Depression2Vec.

Depression2Vec corpus

We collected 15044 posts from online mental health forums, social media posts created by people suffering from mental health illness.

Type	Statistics
Corpus size (Number of posts)	15044
Number of sentences	133524
Average sentences per post	8.87
Number of words	3502245
Average words per post	232
Training set size (Number of posts)	14944
Testing set size (Number of posts)	100

Depression2Vec method

input : Corpus

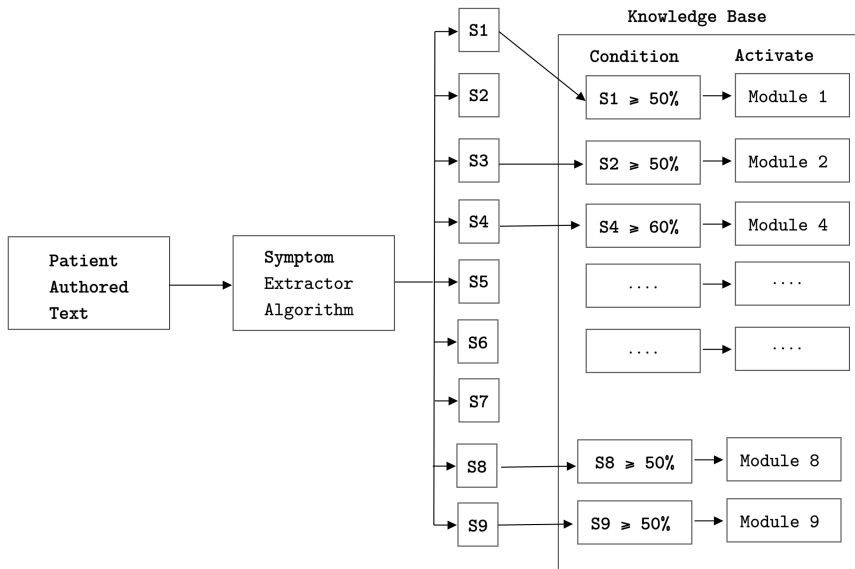
output: Trained embedding

```
1 foreach doc  $d \in \text{corpus}$  do
2    $d \leftarrow \text{algorithm}_1(d)$ ;
3   foreach term  $t \in d$  do
4     synonyms  $\leftarrow \text{wordnet.synonyms}(t)$ ;
5     foreach synonym  $w \in \text{synonyms}$  do
6       terms  $\leftarrow \text{wordnet.hyperonym}(w)$ ;
7       terms  $\leftarrow \text{wordnet.hyponym}(w)$ ;
8       terms  $\leftarrow \text{wordnet.antonyms}(w)$ ;
9     end foreach
10  end foreach
11  vocabulary  $\leftarrow \text{terms}$ ;
12 end foreach
13 Embedding  $\leftarrow \text{word2vec}_{\text{skipgram}}(\text{vocabulary}, \text{corpus}, \text{window} = 2)$ ;
14 return seed_terms
```

Results

Symptoms	Methods	TPR	FNR	ACC	Fscore
1	USE	0.00	1.00	0.59	0.44
	Glove	0.00	1.00	0.59	0.44
	WN	1.00	0.00	1.00	1.00
	DP2Vec	0.98	0.02	0.99	0.99
2	USE	0.00	1.00	0.04	0.00
	Glove	0.00	1.00	0.04	0.00
	WN	1.00	0.00	1.00	1.00
	DP2Vec	0.97	0.03	0.97	0.97
3	USE	0.00	1.00	0.76	0.66
	Glove	0.00	1.00	0.76	0.66
	WN	1.00	0.00	1.00	1.00
	DP2Vec	0.92	0.08	0.98	0.98
4	USE	0.00	1.00	0.61	0.46
	Glove	0.00	1.00	0.61	0.46
	WN	1.00	0.00	1.00	1.00
	DP2Vec	0.95	0.05	0.98	0.98
5	USE	0.00	1.00	0.93	0.90
	Glove	0.00	1.00	0.93	0.90
	WN	0.43	0.57	0.96	0.95
	DP2Vec	0.86	0.14	0.99	0.99
6	USE	0.00	1.00	0.57	0.41
	Glove	0.00	1.00	0.57	0.41
	WN	1.00	0.00	1.00	1.00
	DP2Vec	0.98	0.02	0.99	0.99
7	USE	0.00	1.00	0.87	0.81
	Glove	0.00	1.00	0.87	0.81
	WN	1.00	0.00	1.00	1.00
	DP2Vec	0.92	0.08	0.99	0.99
8	USE	0.00	1.00	0.97	0.96
	Glove	0.00	1.00	0.97	0.96
	WN	1.00	0.00	1.00	1.00

Adaptive strategy



- Complex negated sentences (e.g., *The doctor says he does not have any explanation for my mild depression.*)
- Conditional sentences (e.g., *If I experience sleeping issue, I will consult a psychiatrist.*),
- Uncertain sentences (e.g., *I'm not sure if I have a speaking issue or if I interrupt others too much.*), and
- Statements about history or family history (e.g., *I do not exhibit any symptoms, particularly; however, my mother has a severe headache and concentration issues.*)

- 1 Validate corpus with domain experts (psychiatrist, linguists)
- 2 Detect Internet slang, correct spellings, and abbreviations before creating embedding.
- 3 Attempt to validate and study the effects of complex negation.
- 4 New language models are made available GPT-3 language model, transformer. Compare Depression2Vec with the latest model.
- 5 Validate the effect of adaptation in clinical setup and user adherence.

Conclusion

- 1 Our objective is to use the symptoms extraction technique to tailor Internet interventions based on the patients' current context. To achieve such adaptability, a substantial accuracy of the symptoms extraction technique can work.
- 2 IDPT is generally targeted for people with low or mild mental health issues. Hence, a false positive recommendation of a module or any other psychoeducation material will not have any impact on the patients' health.

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