



TBD3: A Thresholding-Based Dynamic Depression Detection from Social Media for Low-Resource Users

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LREC 2022

<https://github.com/Georgetown-IR-Lab/lrec2022-tbd3>



Depression the tip of iceberg

Depression affects between 3% (UN, 2017) and 5% (WHO, 2021) of the global population

Can lead to negative outcomes like suicide, self-harm, dementia, and premature mortality

Early depression detection is crucial for preventing exacerbation

Heavy usage of social media by users to share their mental health concerns and diagnoses has turned it into large scale resource for detecting mental health conditions

Motivation: Discrepancy in Stratified Dataset

Low-resource users are the users with short posting histories

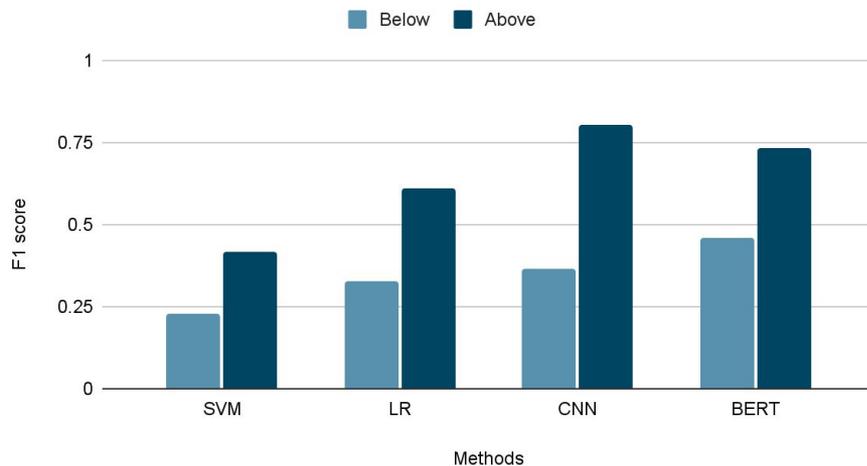
BELOW denotes posts less than median number of posts

ABOVE denotes posts greater than or equal to median number of posts

A difference of at least 0.2 in F1 score is observed between BELOW and ABOVE segments for all methods

Performance of existing methods dips remarkably in the case of low-resource users

Discrepancy in Stratified Dataset





Hypothesis

Changing the sensitivity of ML model by dynamically adjusting the threshold value leads to effective identification of depression in low-resource users.



Calculation of threshold

A validation set is used to determine the ideal threshold value

Ideal threshold is the threshold where F1 score is maximized on the validation set

$$th_{ideal} = th[\arg \max_i (F1[i])]$$

Here, th is the set of possible thresholds with $th[i]$ being the i^{th} possible threshold

$F1[i]$ denotes the $F1$ score corresponding to the i^{th} threshold value for validation set

Impact of thresholding at various stages of posting history on RSDD [1]

Key Inferences: 1. Thresholding improves results 2. Thresholding delivers higher impact for less number of posts

First	Thr.	SVM			LR			CNN			BERT		
		F1	Prec	Recall									
100	def.	0.003	0.667	0.001	0.351	0.287	0.450	0.033	0.961	0.017	0.237	0.716	0.142
100	tun.	0.310	0.326	0.295	0.376	0.404	0.352	0.430	0.411	0.451	0.404	0.370	0.445
200	def.	0.045	0.651	0.023	0.391	0.334	0.470	0.133	0.922	0.072	0.385	0.662	0.271
200	tun.	0.351	0.350	0.353	0.413	0.350	0.402	0.481	0.432	0.541	0.460	0.478	0.444
300	def.	0.130	0.655	0.072	0.413	0.359	0.485	0.252	0.901	0.147	0.454	0.635	0.353
300	tun.	0.367	0.311	0.448	0.428	0.411	0.447	0.526	0.569	0.489	0.492	0.533	0.457
400	def.	0.235	0.600	0.146	0.423	0.371	0.491	0.369	0.899	0.232	0.508	0.636	0.422
400	tun.	0.388	0.332	0.467	0.435	0.428	0.442	0.552	0.546	0.559	0.520	0.510	0.530
All	def.	0.386	0.279	0.624	0.471	0.415	0.544	0.692	0.814	0.602	0.643	0.619	0.669
All	tun.	0.474	0.577	0.403	0.481	0.486	0.476	0.681	0.717	0.648	0.651	0.673	0.630

def: default, tun: tuned

Precision vs Recall

Precision vs Recall for first 100, 200, 300, 400 and all posts of each user for all methods

Area under the curve increases with increase in the number of posts under consideration

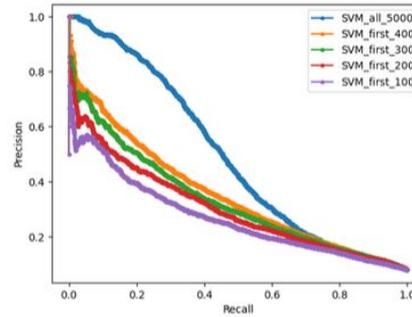


Figure 3: Precision vs Recall for SVM on first n posts

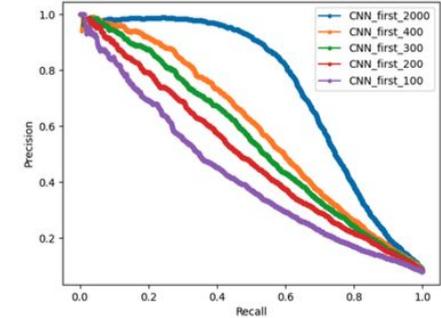


Figure 5: Precision vs Recall for CNN on first n posts

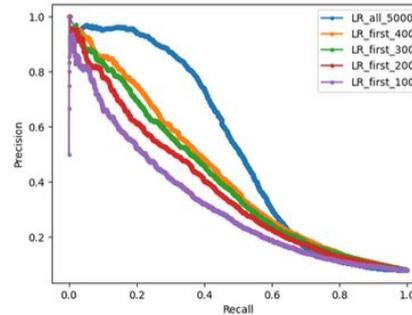


Figure 4: Precision vs Recall for LR on first n posts

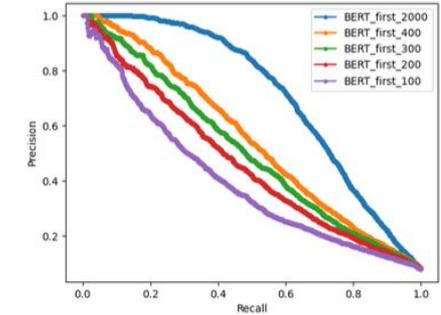


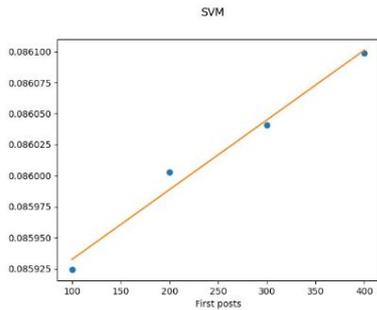
Figure 6: Precision vs Recall for BERT on first n posts

Model for dynamic threshold

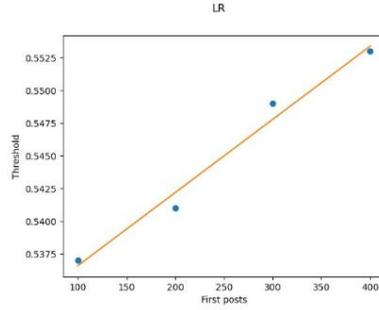
Thresholds were obtained for first 100, 200, 300, 400 posts using validation set

Linear Regression fitted on the obtained thresholds for all four methods depicted in the figure below

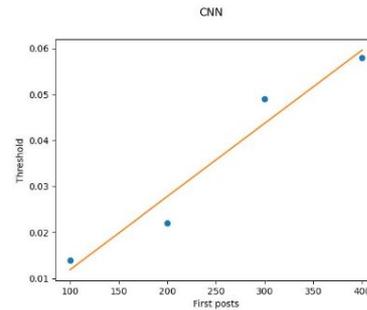
Threshold for first n posts for respective methods can be obtained



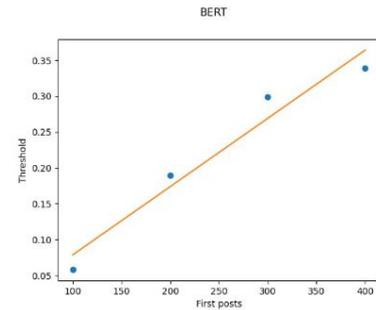
(a)



(b)

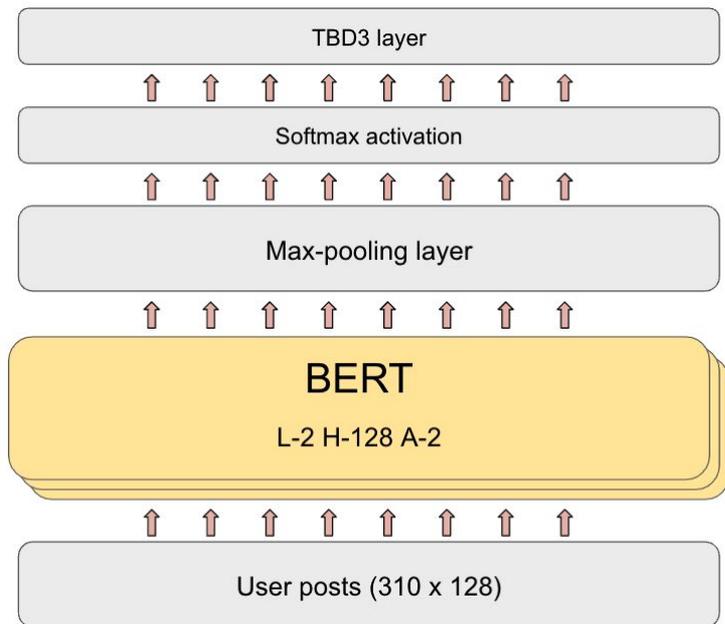


(c)

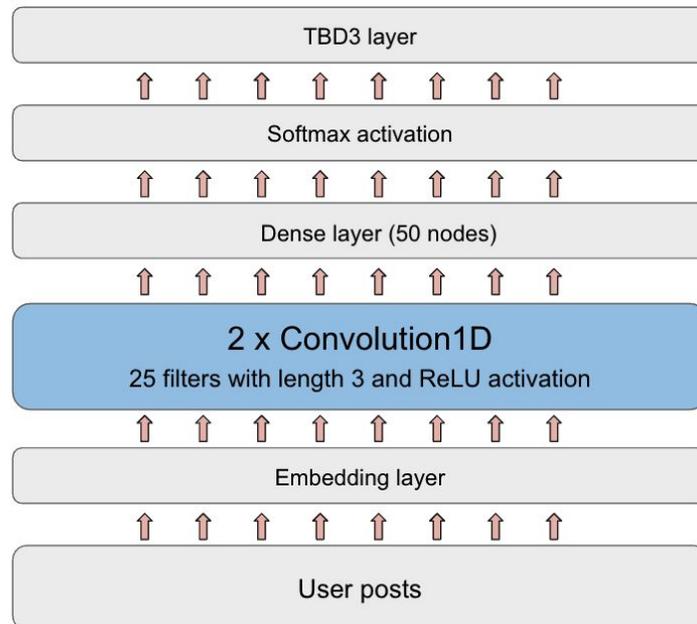


(d)

System Architecture



BERT based system architecture with TBD3 layer



CNN based system architecture with TBD3 layer

Impact of dynamic thresholding

Limited i.e. 20% and 40% initial user posts considered to simulate a dynamic scenario

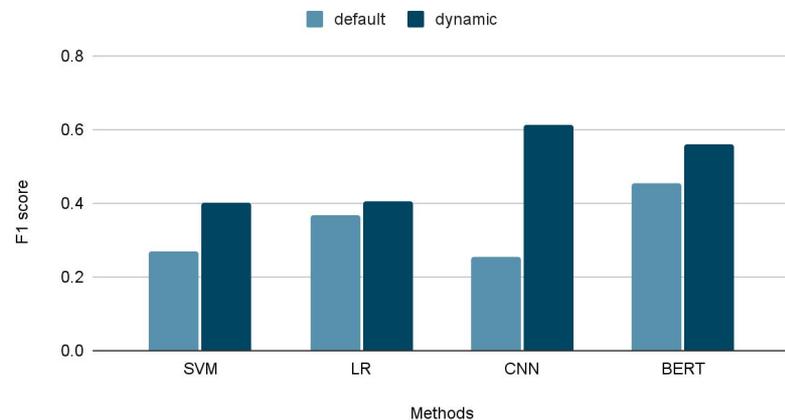
SVM				
Posts	Threshold	F1	Prec	Recall
20% Posts	default	0.269	0.861	0.159
20% Posts	dynamic	0.401	0.461	0.355
40% Posts	default	0.403	0.501	0.337
40% Posts	dynamic	0.434	0.432	0.435

LR				
Posts	Threshold	F1	Prec	Recall
20% Posts	default	0.366	0.306	0.457
20% Posts	dynamic	0.405	0.430	0.383
40% Posts	default	0.410	0.354	0.489
40% Posts	dynamic	0.444	0.453	0.435

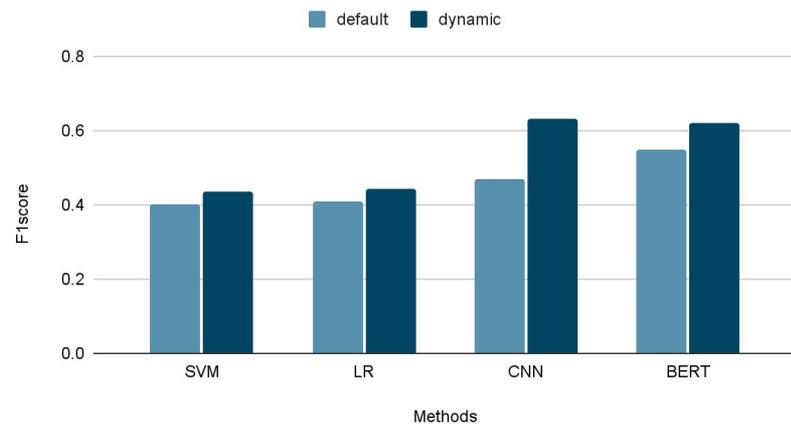
CNN				
Posts	Threshold	F1	Prec	Recall
20% Posts	default	0.255	0.986	0.146
20% Posts	dynamic	0.613	0.748	0.520
40% Posts	default	0.468	0.982	0.307
40% Posts	dynamic	0.632	0.676	0.593

BERT				
Posts	Threshold	F1	Prec	Recall
20% Posts	default	0.453	0.899	0.303
20% Posts	dynamic	0.561	0.592	0.532
40% Posts	default	0.584	0.825	0.452
40% Posts	dynamic	0.621	0.655	0.590

Impact of dynamic thresholding on 20% user posts



Impact of dynamic thresholding on 40% user posts





Findings

- Lesser the number of posts, more impactful is TBD3
- Significant increase in F1 scores for both 20% and 40% posts is observed
- Number of posts and ideal threshold has a linear relation
- TBD3 highly impactful for low-resource users in early depression detection

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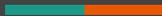
Resource

Low-resource social media users can be simulated with combinations of below listed filters for further research

- Percentage: For low-resource users with dynamic number of posts
- Part: First, Last or Random selection of posts
- Max_Posts: Maximum number of posts considered per user
- Median: Only the users with more than median number of posts considered

<https://github.com/Georgetown-IR-Lab/lrec2022-tbd3>

This resource works on top of RSDD [1] dataset

A horizontal bar with a teal segment on the left and an orange segment on the right, positioned above the title.

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Thank You!

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References



- [1] Yates, A., Cohan, A., and Goharian, N. (2017). Depression and self-harm risk assessment in online forums. In Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing, pages 2968–2978, Copenhagen, Denmark, September. Association for Computational Linguistics.
- [2] UN. (2017). United nations depression. United Nations News. Accessed: 2021-30-12.
- [3] WHO. (2021). World health organization depression. World Health Organization News. Accessed: 2021- 30-12.



Extra Slides



Threshold for first n posts for respective methods

SVM: $th = 5.63e-07*n+0.0859$

LR: $th = 5.59e-05*n+0.5310$

CNN: $th = 1.59e-04*n-0.0039$

BERT: $th = 9.52e-04*n-0.0165$

Empirically cutoff values established for very high and very low number of posts



SVM				
Segment	Threshold	F1	Prec	Recall
BELOW	default	0.227	0.339	0.171
BELOW	0.083676	0.264	0.224	0.322
ABOVE	default	0.416	0.274	0.868
ABOVE	0.084480	0.586	0.668	0.523

LR				
Segment	Threshold	F1	Prec	Recall
BELOW	default	0.327	0.236	0.531
BELOW	0.646	0.374	0.352	0.400
ABOVE	default	0.608	0.671	0.555
ABOVE	0.648	0.607	0.734	0.518

CNN				
Segment	Threshold	F1	Prec	Recall
BELOW	default	0.365	0.790	0.237
BELOW	0.214	0.441	0.612	0.344
ABOVE	default	0.802	0.852	0.758
ABOVE	0.473	0.803	0.844	0.767

BERT				
Segment	Threshold	F1	Prec	Recall
BELOW	default	0.459	0.423	0.502
BELOW	0.599	0.484	0.516	0.456
ABOVE	default	0.731	0.702	0.763
ABOVE	0.625	0.744	0.788	0.704