

DeepMood: Forecasting Depressed Mood Based on Self-Reported Histories via Recurrent Neural Networks



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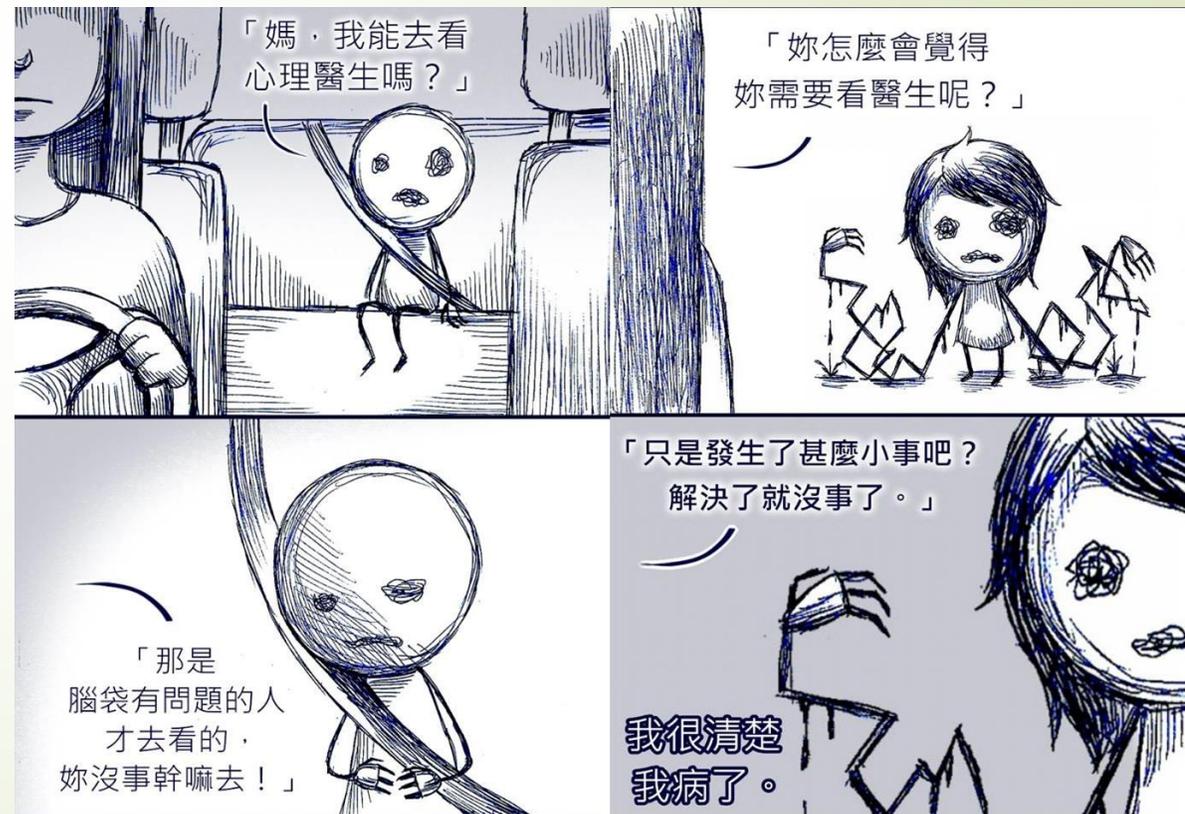
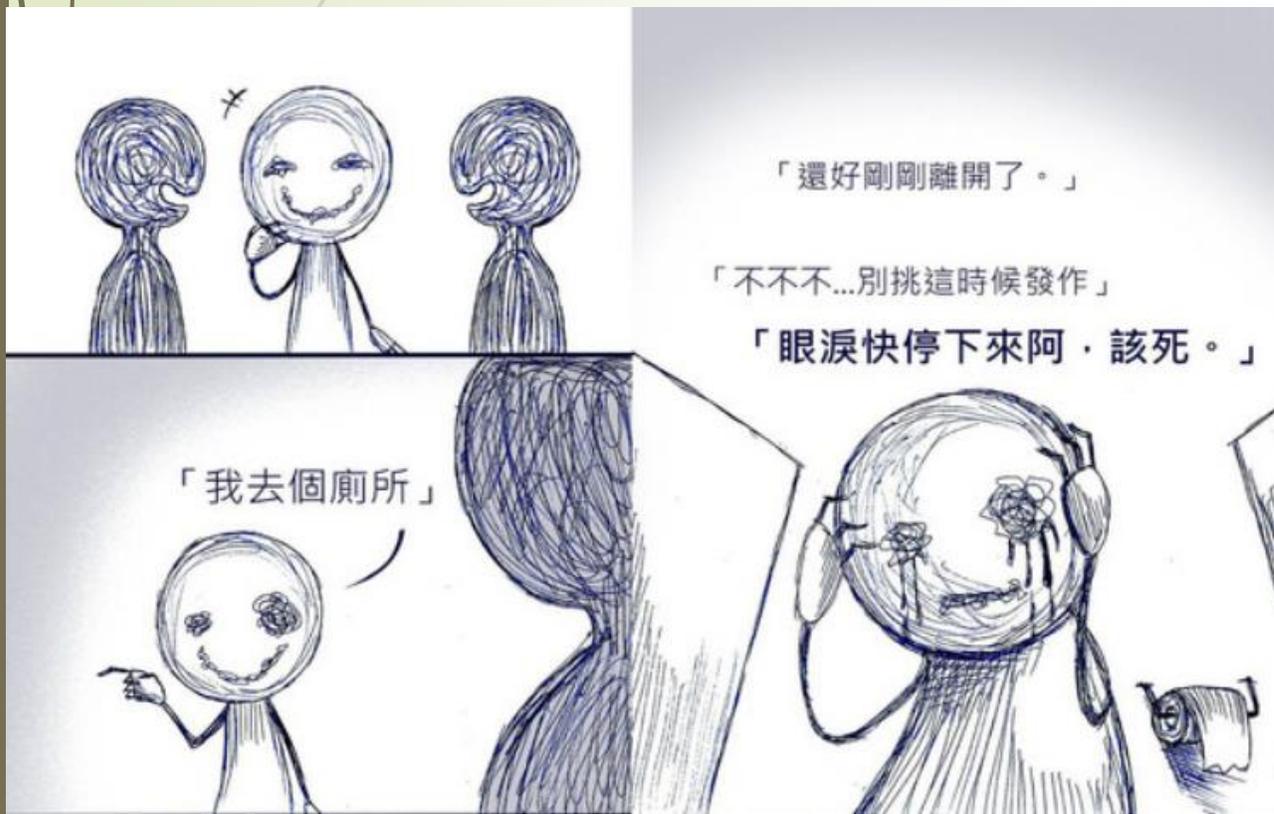


Outline

- Introduction
 - Relation work
 - Method
 - Experiment
 - Conclusion
- 

Introduction

► Motive





Introduction

➤ Goal

With our large dataset, we used a supervised machine learning technique to build a predictive model for forecasting severe depression.



Research question

- RQ1: “Can we forecast severe depression based on individual histories”
 - RQ2: “How many days do we need to look back to forecast severe depression?”
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Introduction

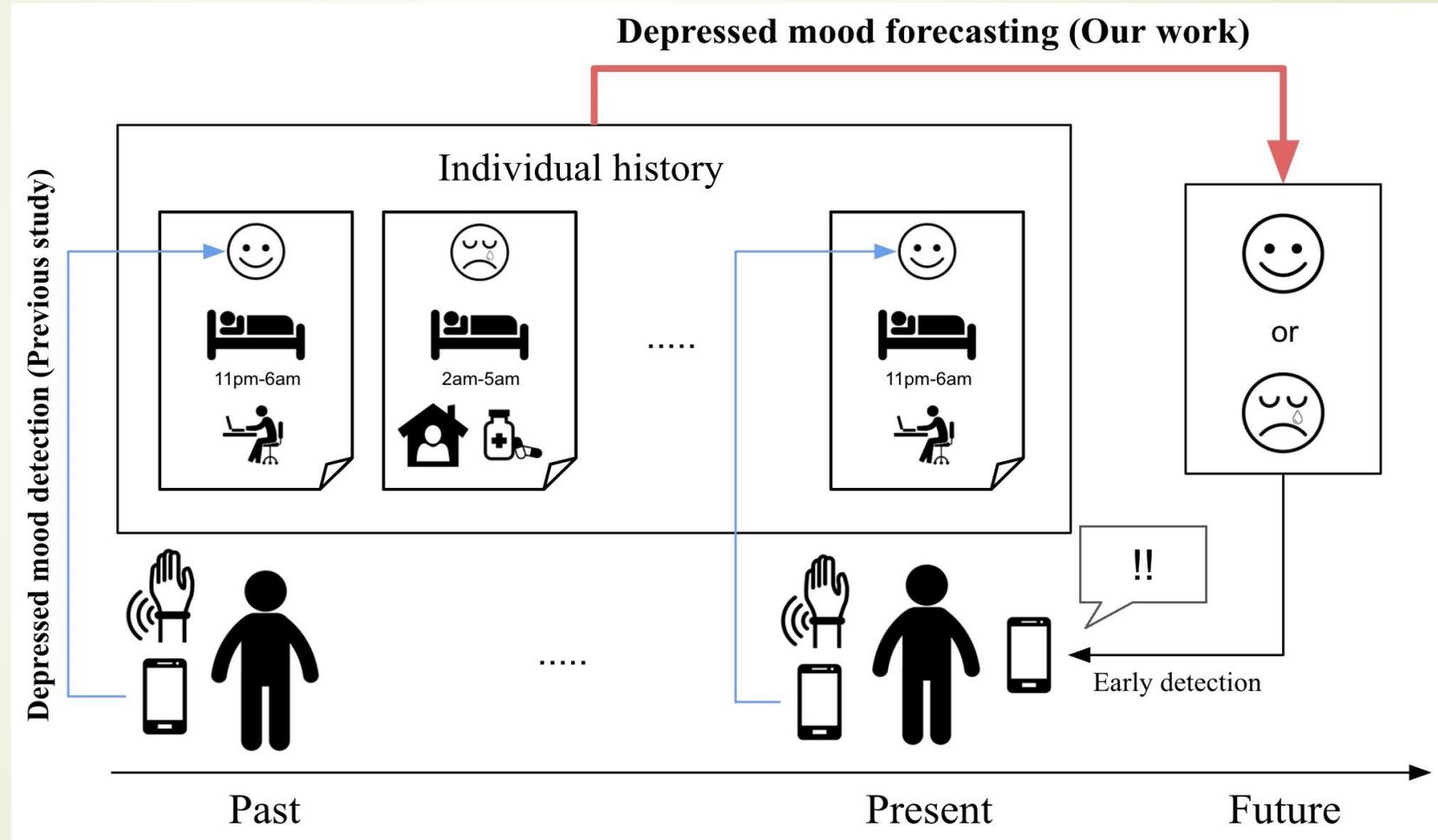


Figure 1: Shows the methodological relationship between this paper and previous studies.

うつレコ～うつ病の人のための行動記録ツール～ (憂鬱記録～為憂鬱症的人的行動記録工具)

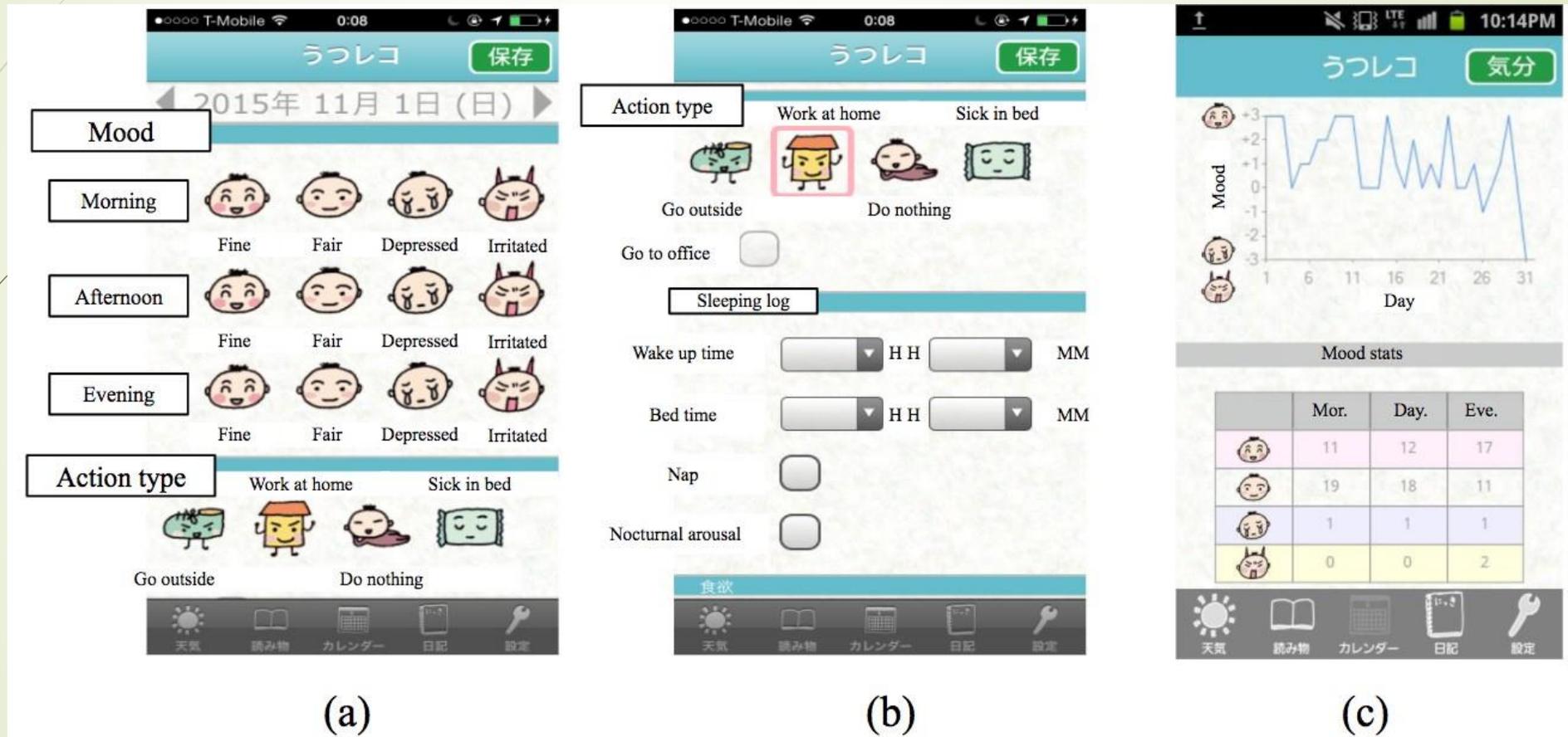
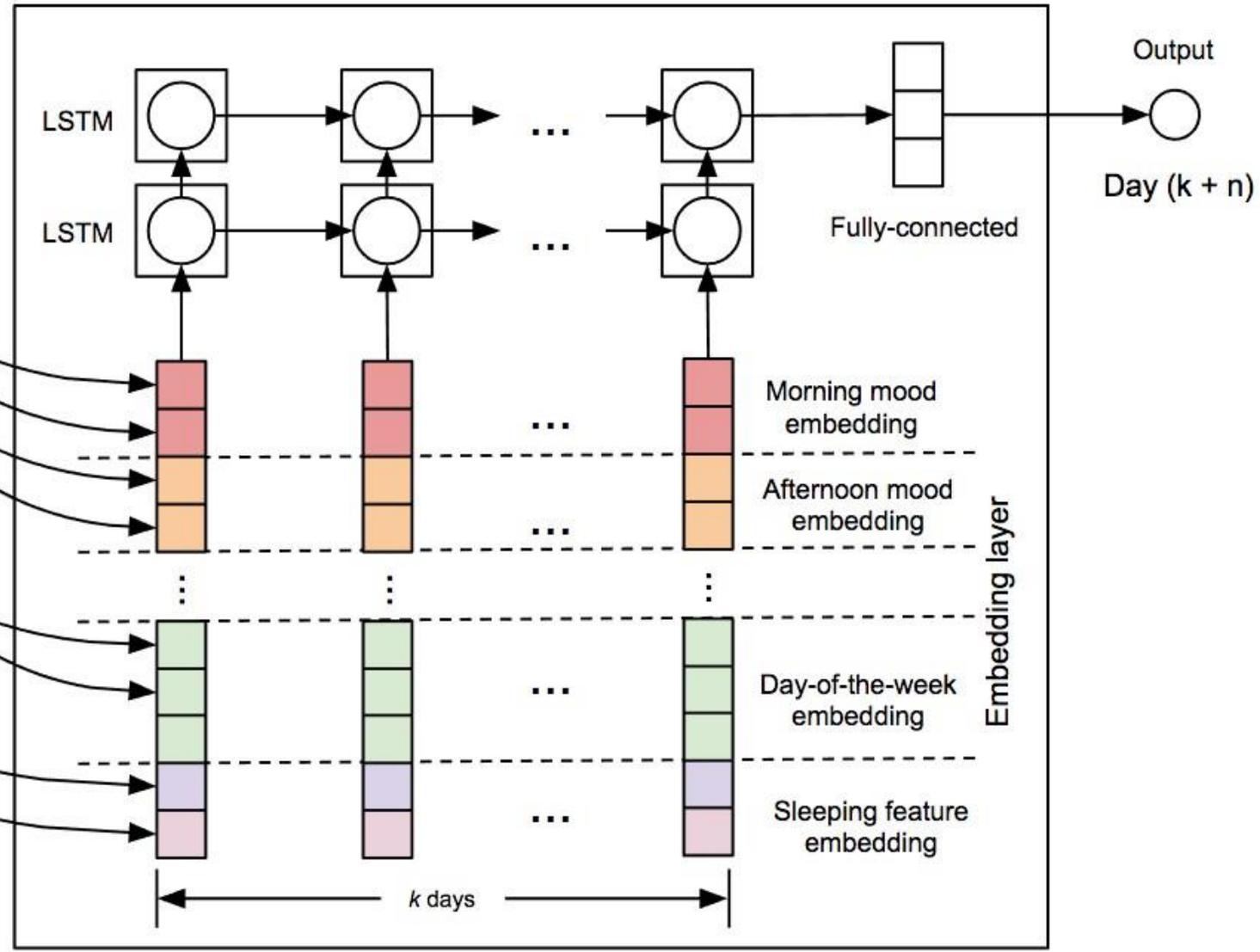
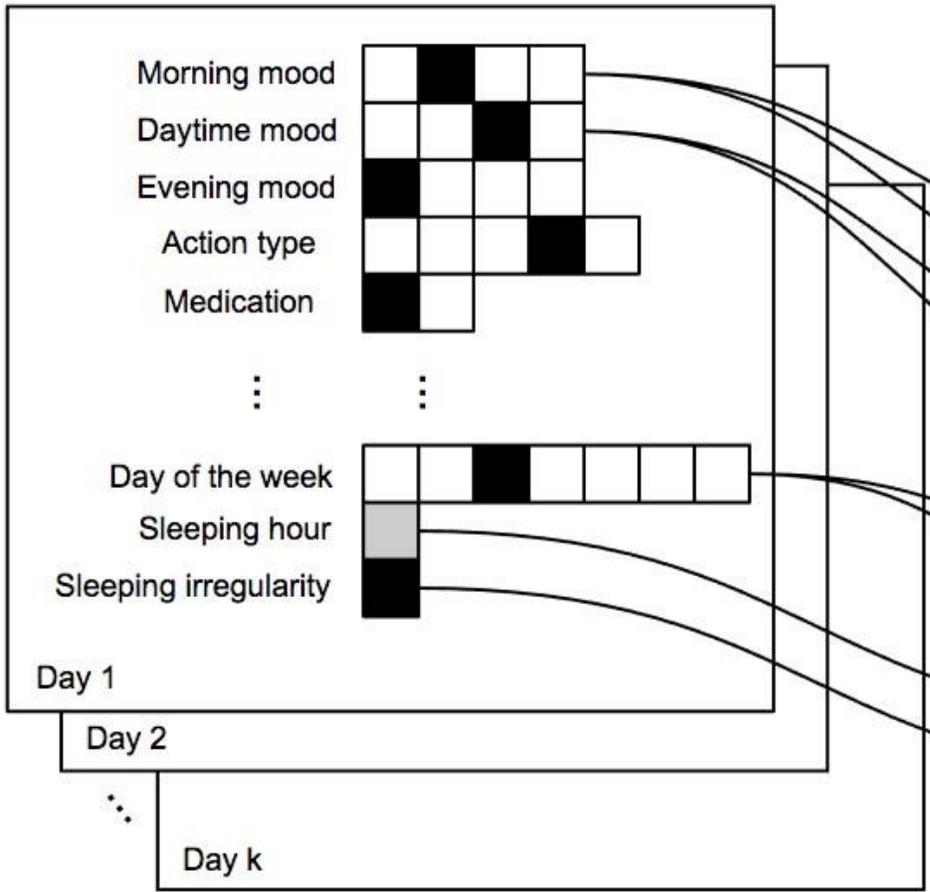


Figure 2: Screenshots of the application used for collecting self-reported histories.

Network architecture of our method

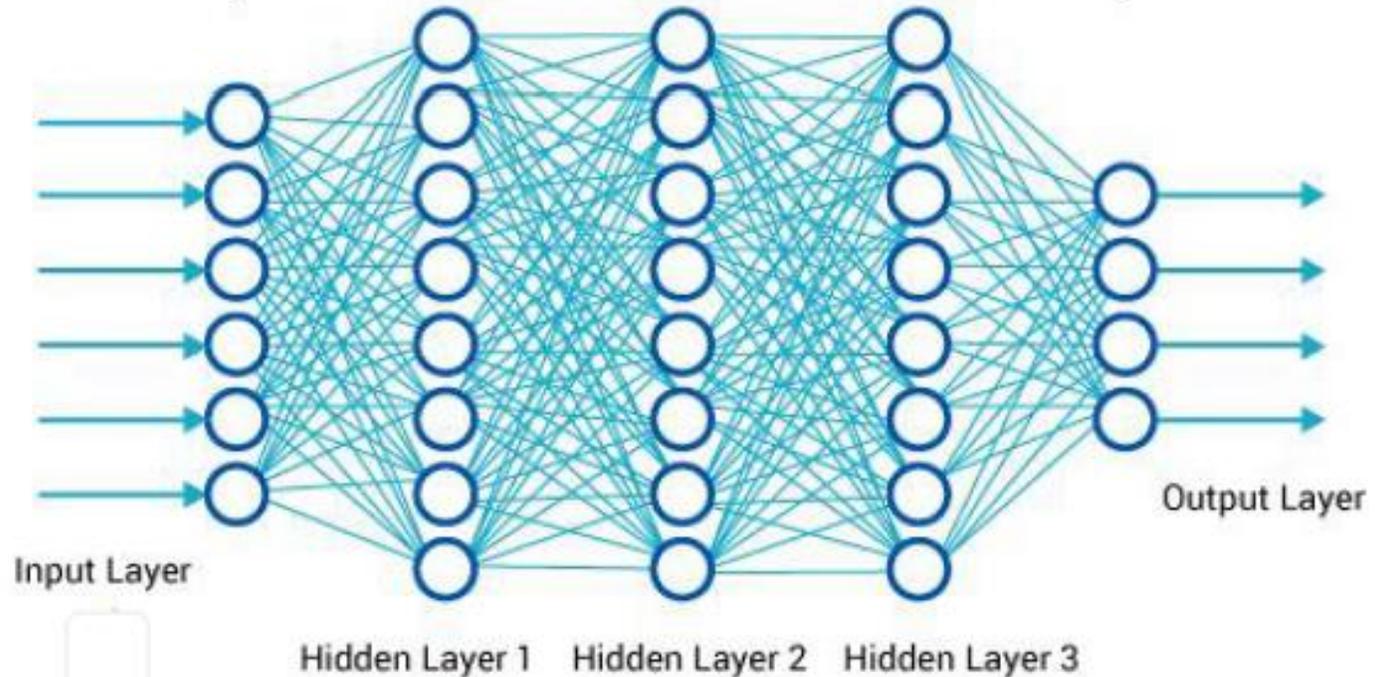
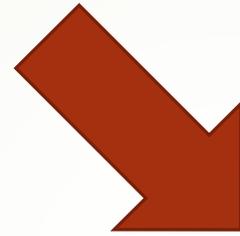




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- 

Neural network



Recurrent neural network (RNN)

Input data: x^1 x^2 x^3 x^N

Input:
2 dimensions

x^1	x^2	x^3
4	4	1
7	7	1

Output:
1 dimension

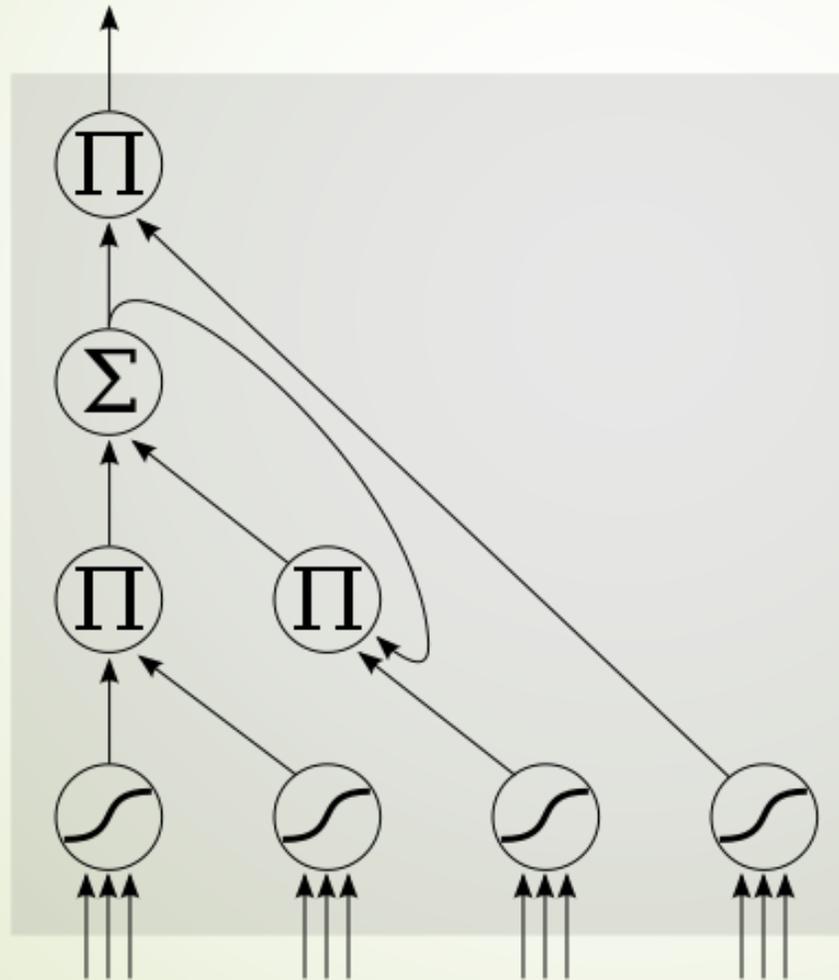
\hat{y}^1	\hat{y}^2	\hat{y}^3
1	2	3

	1	1	
	1	4	4
+	1	7	7
<hr/>			
	3	2	1

Network needs memory
to achieve this

Output y^i depends on x^1, x^2, \dots, x^i

Long Short-Term Memory, LSTM-RNN (this paper)





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Method - Preliminaries

- **Definition 1.** A user experiences a **severe depression** day if the user has **negative feelings** (i.e., depressed or irritated) **all day** and **exhibits inactive behavior** in which he or she avoids leaving home.
- **Definition 2.** (n, k)-day severe depression forecast
A user will experience **at least one severe depression day in the coming n days** based on **the user's history during the last k days**.

Problem Formulation

- Given individual histories, the task is to forecast the **existence of severe depression day in n days**

EX: (1, 14)-day severe depression forecast is used to forecast a user's severe depression on a coming day based on the histories of the last two weeks.

- $X_t^u \in X^u$

A feature vector extracted from the input of a user u in day t is denoted

- Y_t^u

The severe depression label, if $n = 1$, or otherwise a period from t to $t + n - 1$.

- **Severe depression forecasting** aims to forecast the severe depression of an individual user Y_t^u based on the user's histories in the previous k days

$$(X_{t-k-1}^u, X_{t-k}^u, \dots, X_{t-1}^u)$$

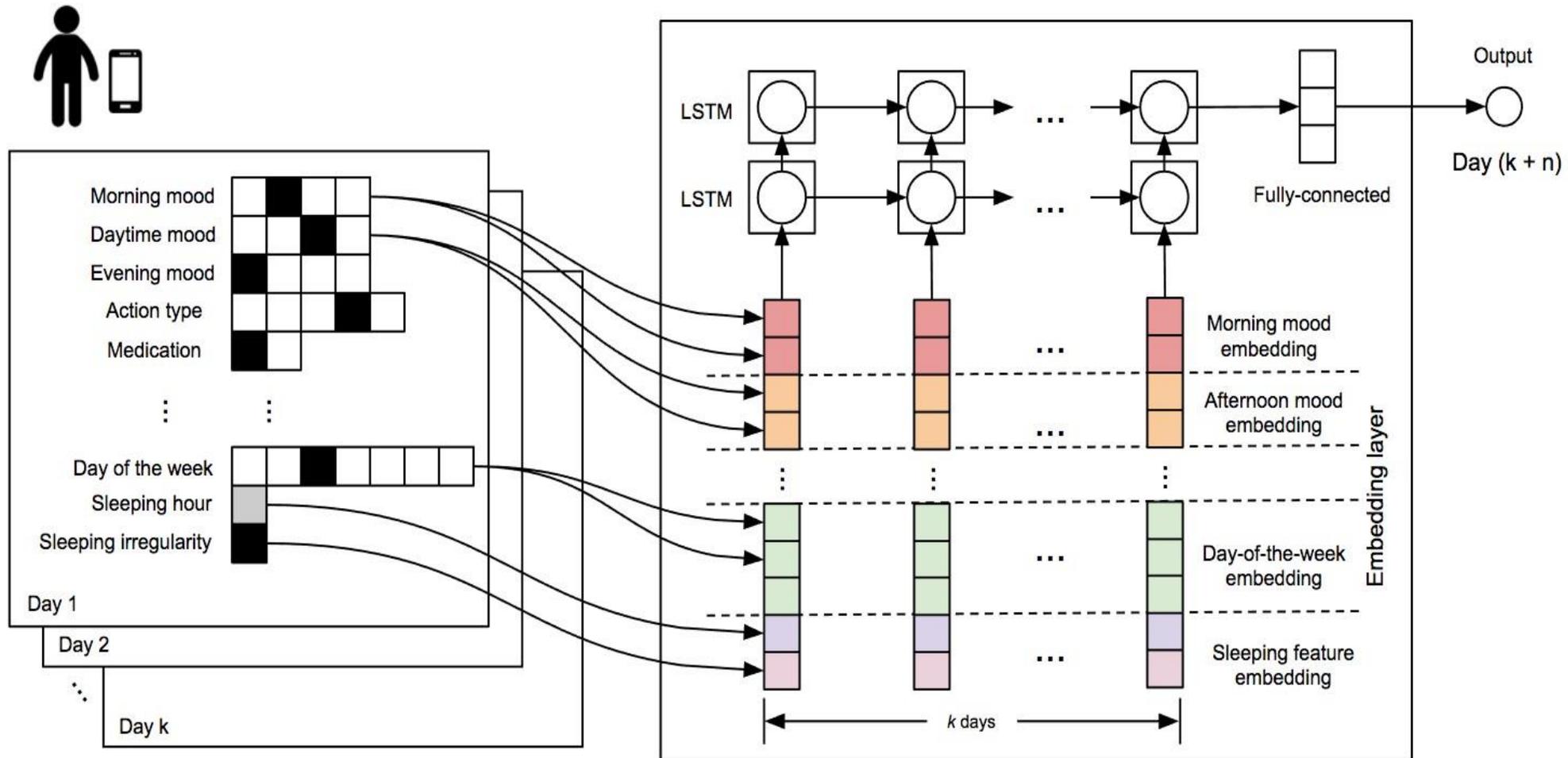
Log information



Table 1: Log information.

Category	Name	Value type
Mood	Morning mood	{fine, fair, depressed, irritated}
	Afternoon mood	
	Evening mood	
Behavioral log	Action type	{Go to work, go outside, work at home, do nothing at home, sick in bed}
	Medication	{yes, no}
	Urgent medication	{yes, no}
	Hospital attendance	{yes, no}
Sleeping log	Bedtime	HH:MM
	Wake-up time	HH:MM
	Nocturnal awakening	{yes, no}
	Taking a nap	{yes, no}

Method





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- 

DATA

- ▶ We **published the smartphone application** in Google Play 2 and the App Store3 **in November 2012**.
- ▶ **November 2012 ~ September 2014**,
 - ▶ 24,211 users.
 - ▶ we filtered out users who had not used the application more than **28 successive days** to ensure adequate history duration for each user.

Table 2: Dataset description.

Total days	345,158
Number of users	2,382
Avg. days / user	144.9
Number of severe / Nonsevere labels	32,205 / 312,953

Experiment

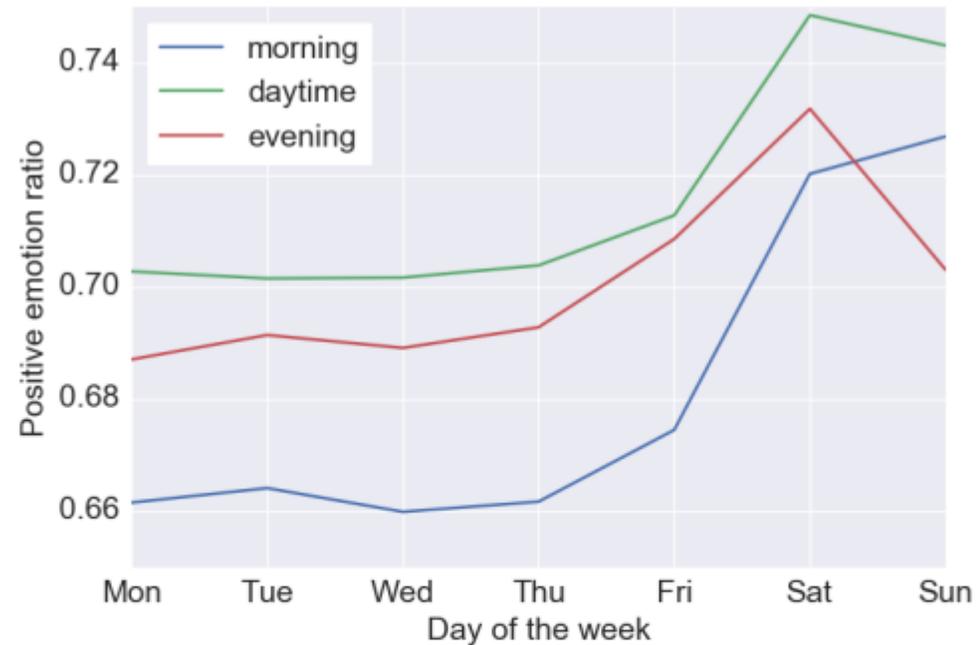
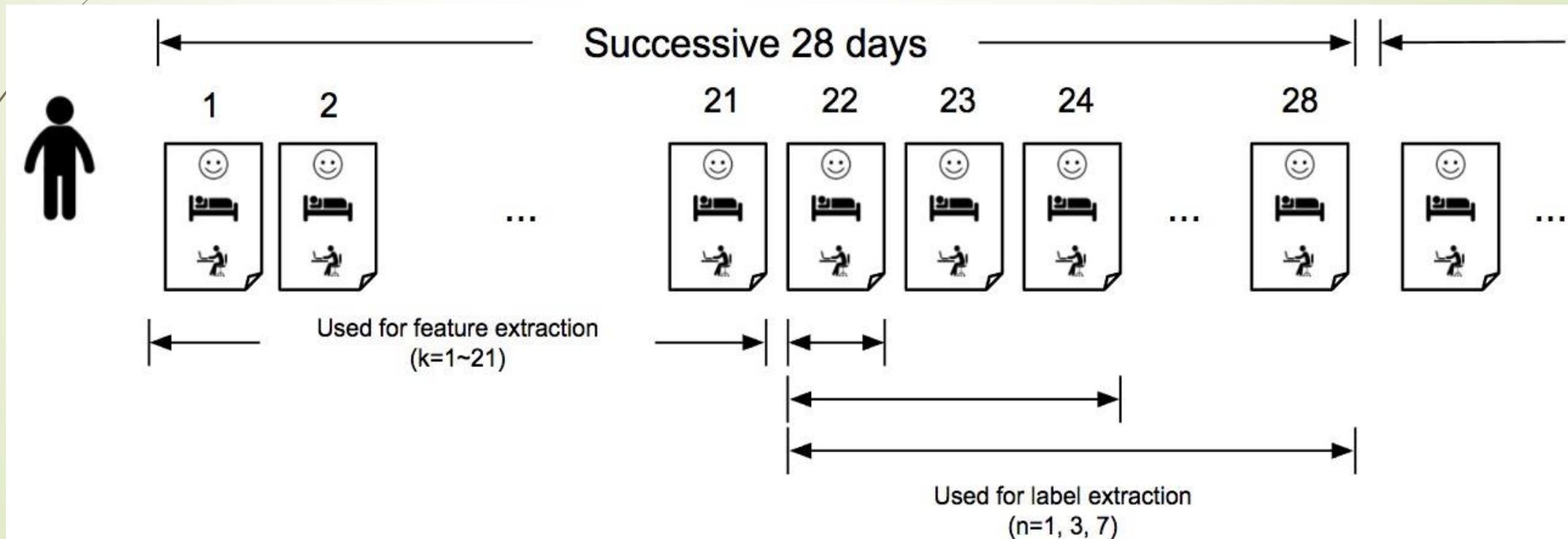


Figure 5: Positive feeling ratio for each day of the week. Each line corresponds to a time period in a day. The positive feeling ratio denotes the ratio of the count of positive feelings (fine or fair) to the total count of any feeling by all users.

Labeled Dataset Creation

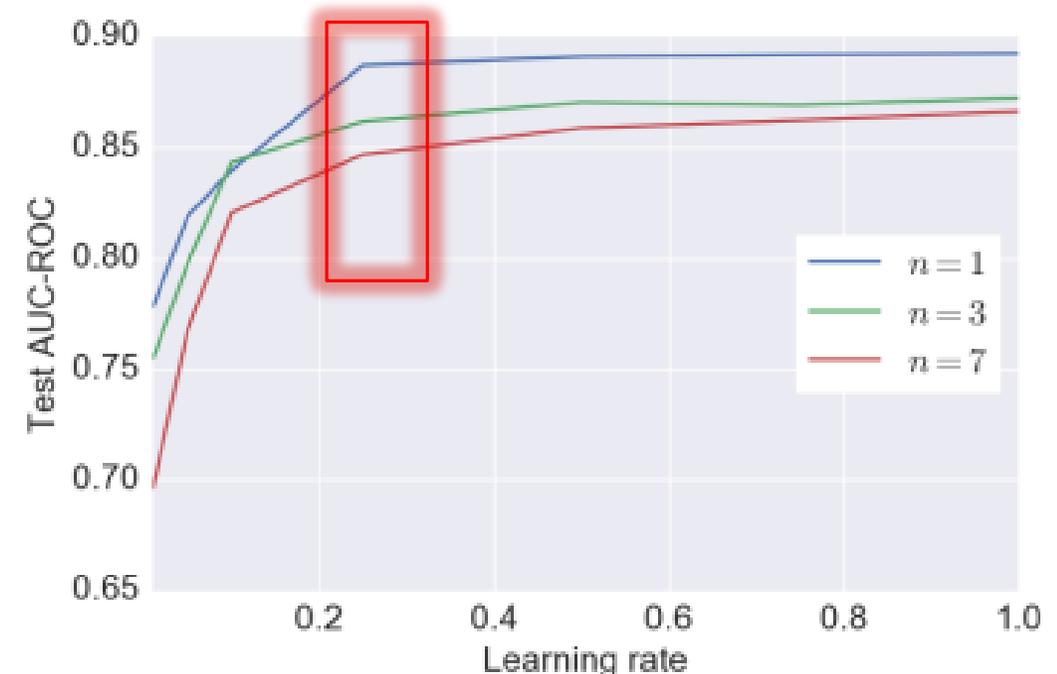
- We set the size as 28 to conduct different experiments(i.e., $n = 1, 3, 7$ and $k = 14, \dots, 21$.) in a consistent manner.
- label extraction method differs for each severe depression task.



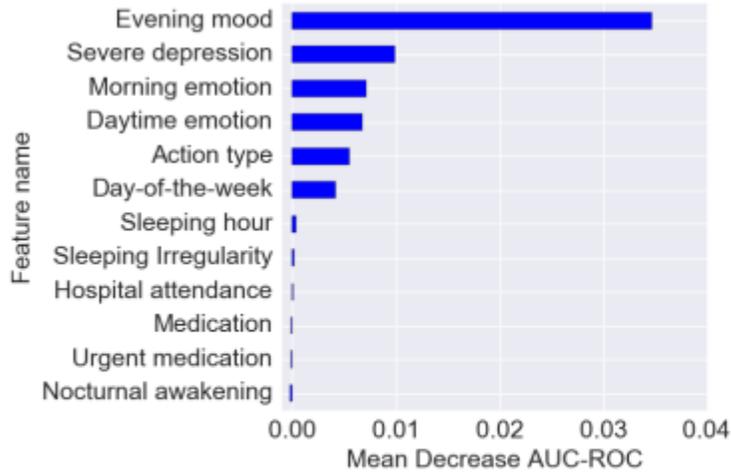
RQ 1: Can we forecast severe depression?

Table 3: Experimental results. The mean value of Test AUC-ROC is listed for each method. The standard deviations are in parentheses. *** denotes $p < 0.01$. The p -values were calculated based on paired t -test after making adjustments using the Holm-Bonferroni method for multiple comparison.

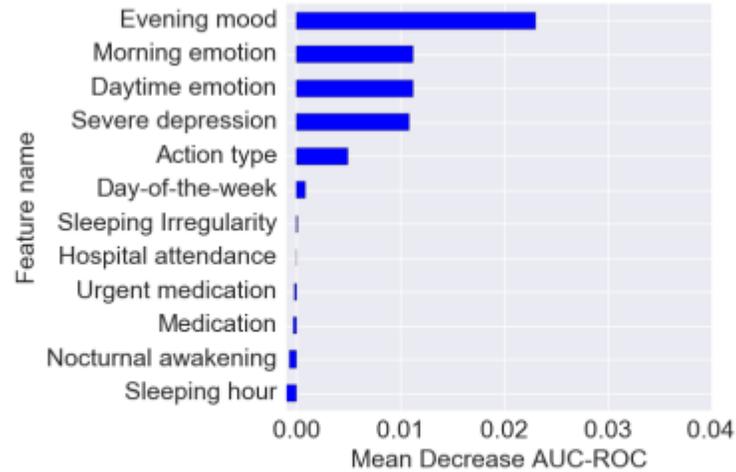
Method (feature set)	AUC-ROC		
	$n = 1$	$n = 3$	$n = 7$
SVM (all)	.837 (.031)	.822 (.045)	.822 (.047)
LSTM-RNN (severe only)	.846 (.032)	.821 (.042)	.800 (.053)
LSTM-RNN (all)	.886*** (.020)	.860*** (.031)	.842*** (.044)



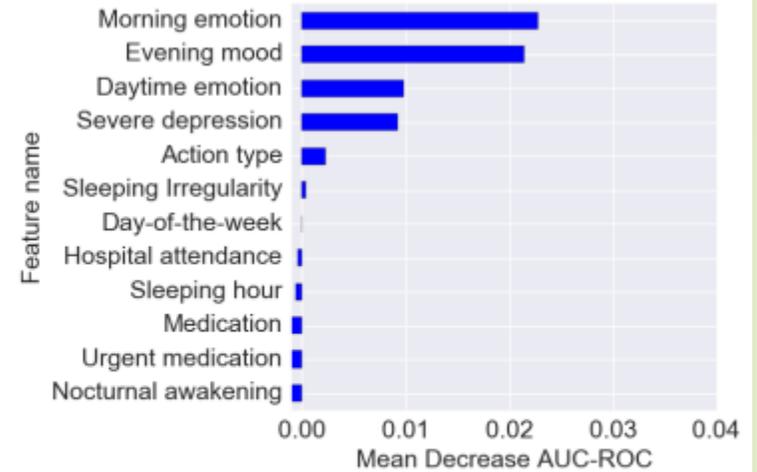
RQ 1: Can we forecast severe depression?



(a)



(b)

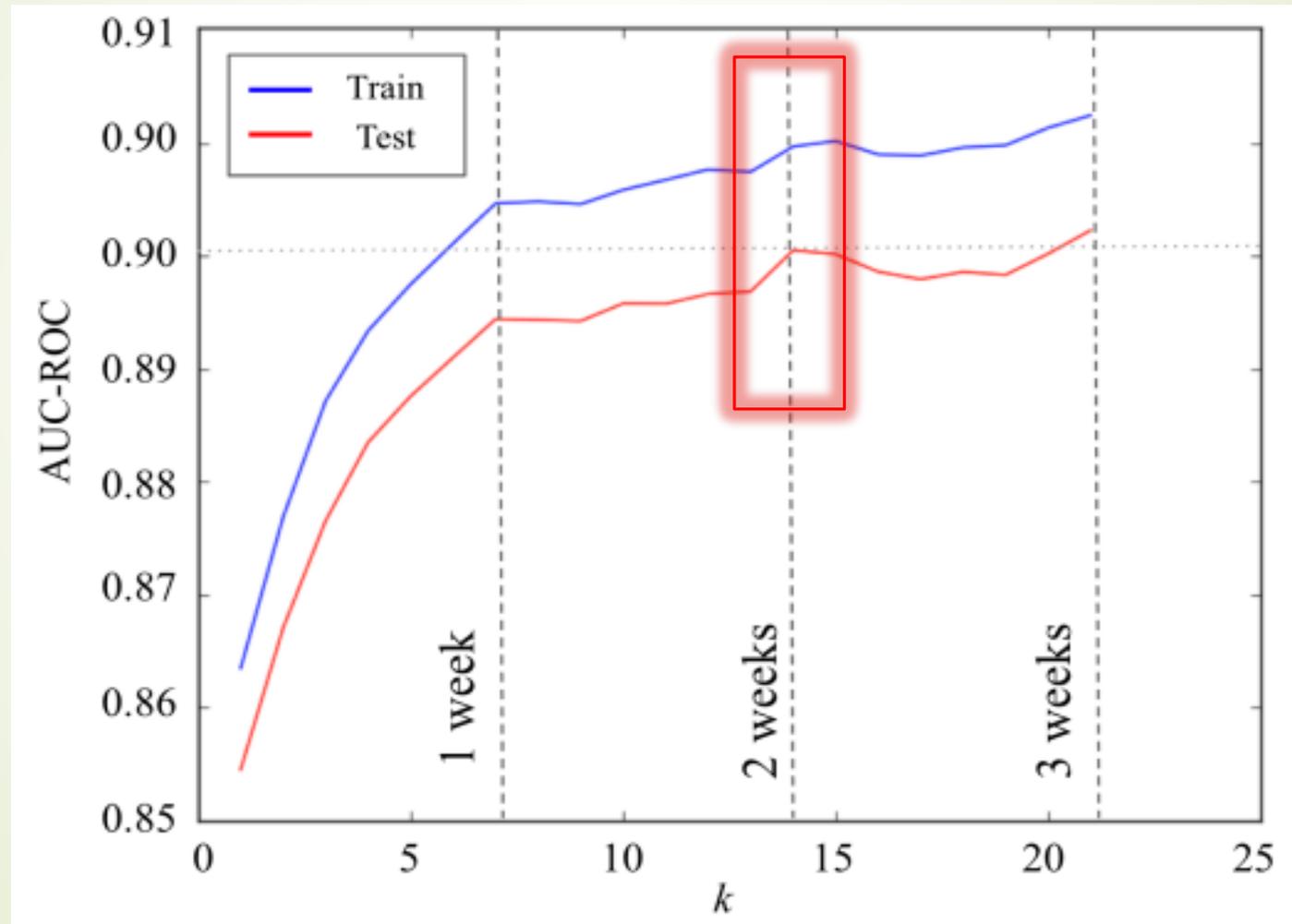


(c)

► Figure 8: (a) Mean Decrease AUC-ROC feature importance for each feature.

(a) $n = 1$, (b) $n = 3$, and (c) $n = 7$

RQ 2: How many days should we look back?





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Conclusion

- ▶ With the largescale data, we utilized the power of deep learning to build a depression forecasting model.
 - ▶ Experimental results confirmed that our framework was able to forecast severe depression based on individual histories with high accuracy.
 - ▶ We believe that this paper is a good step toward automatic depression detection, which could provide appropriate interventions for people and improve well-being in our society.
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