Neural Sequence-to-grid Module for Learning Symbolic Rules

Segwang Kim[1], Hyoungwook Nam[2], Joonyoung Kim[1], Kyomin Jung[1]

[1] Seoul National University, Seoul, Korea

[2] University of Illinois at Urbana-Champaign, Urbana, Illinois, USA

AAAI Association for the Advancement of Artificial Intelligence

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Background

- The **symbolic reasoning problems test models** whether they can systematically extend rules on **out-of-distribution (OOD)** data.

Training examples

5	8	2	+	1	=
6	7	+	3	=	

OOD Test Examples

3	0	5	3	4	+	4	2	1	=	
6	9	5	2	1	+	5	0	0	2	9	=

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- However, deep learning models cannot extend learned rules to OOD examples.

Middle school level mathematics problems [1]

	Parameters	Interpolation	Extrapolation
Simple **LSTM**	18M	0.57	0.41
Simple **RMC**	38M	0.53	0.38
Attentional **LSTM**, LSTM encoder	24M	0.57	0.38
Attentional **LSTM**, bidir LSTM encoder	26M	0.58	0.42
Attentional **RMC**, bidir LSTM encoder	39M	0.54	0.43
Transformer	30M	**0.76**	**0.50**

Accuracy

[1] Saxton, et al. Analysing Mathmatical Reasoning Abilities of Neural Models, ICLR 2019.

Motivation

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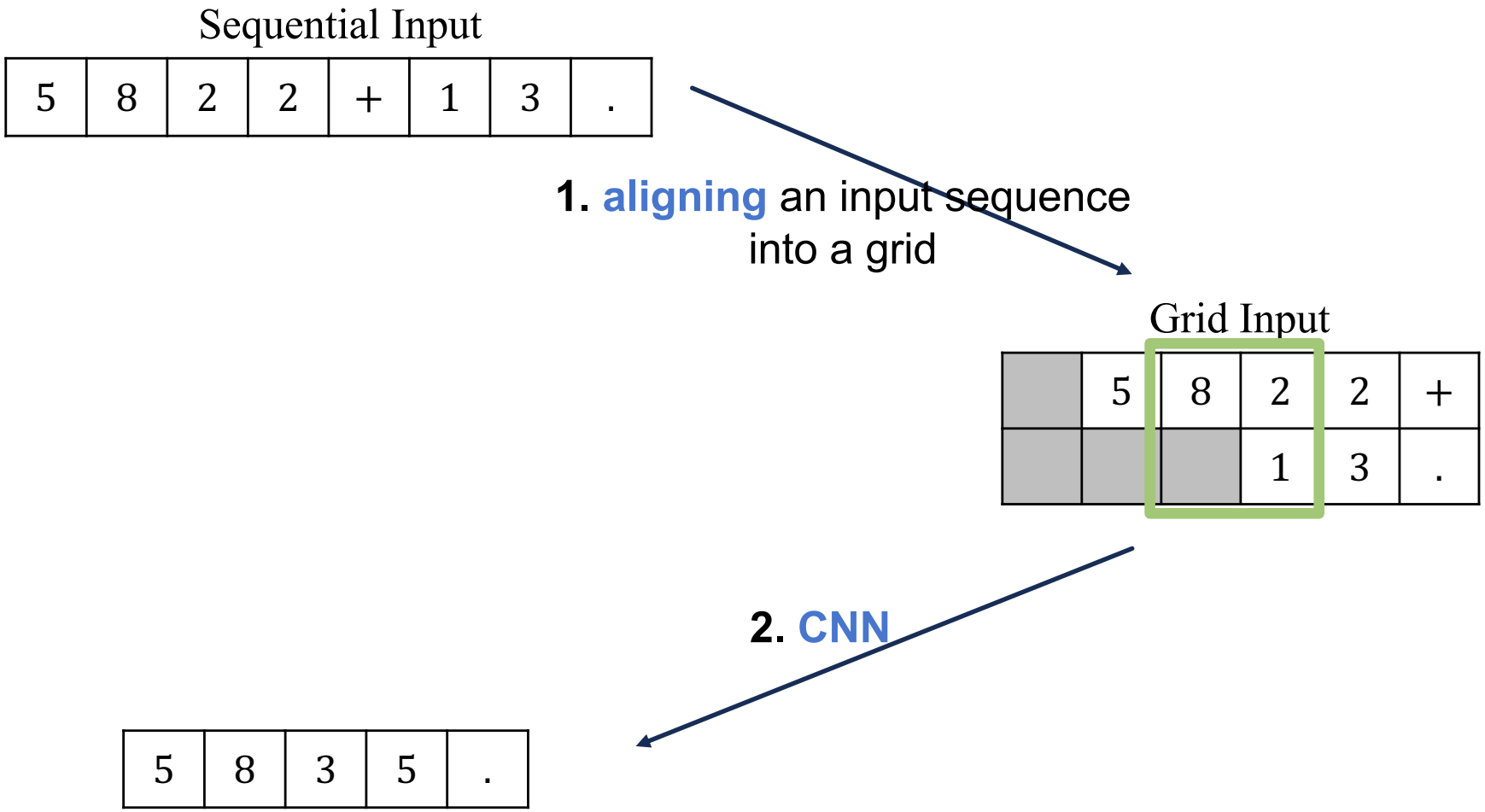

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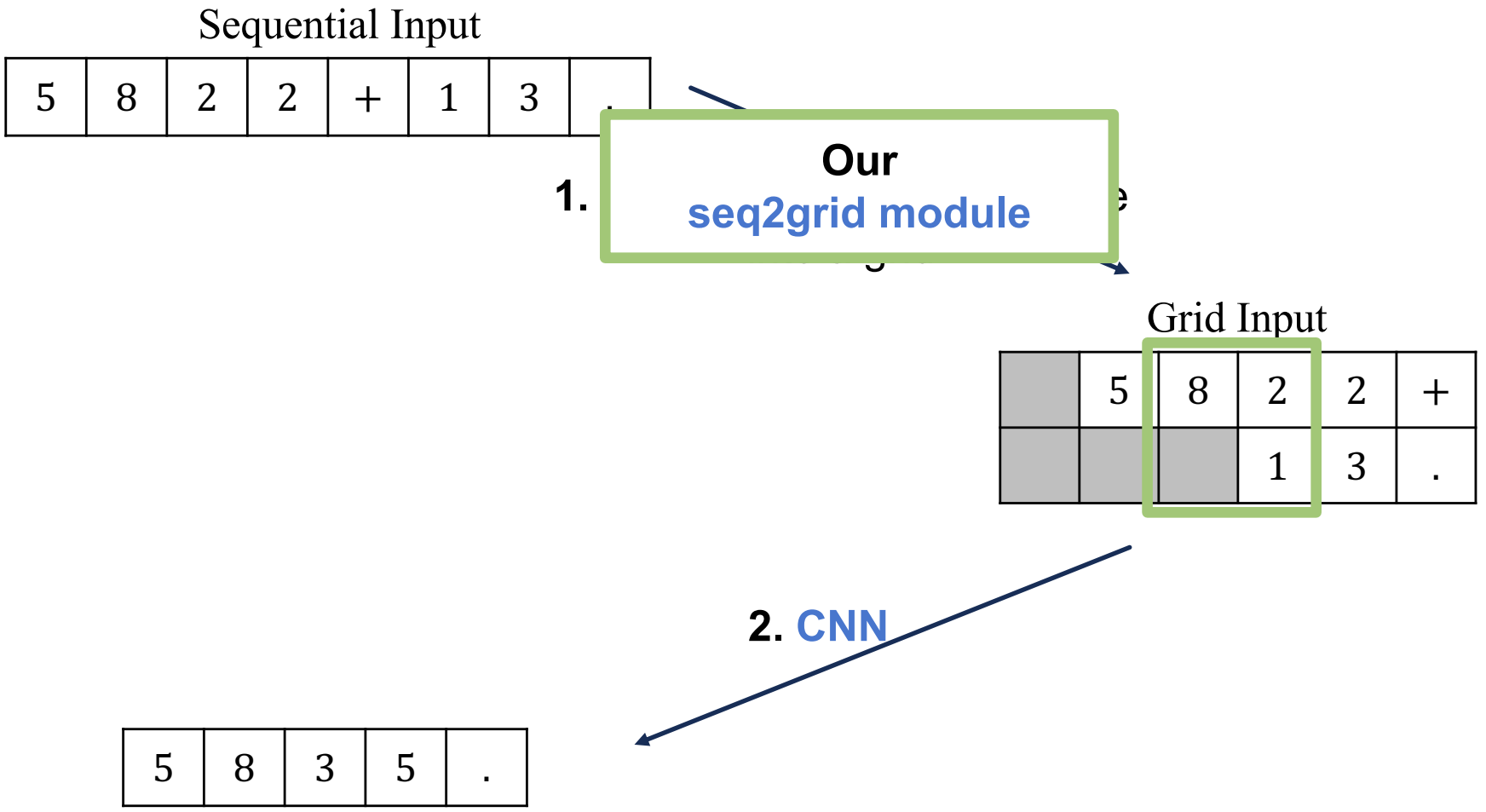

Contribution

- We propose a **neural sequence-to-grid (seq2grid) module**.
  - It **learns how to align** inputs **without supervision**.
  - It can be jointly trained with the CNN **in an end-to-end fashion**.
- Experiments

Input:

```
j=8584
for x in range(8):
  j+=920
b=(1500+j)
print((b+7567))
```

Task 2: Two Supporting Facts

John is in the playground.
John picked up the football.
Bob went to the kitchen.
Where is the football?

	Sequence		Add-or-sub		Program	
	ID	OOD	ID	OOD	ID	OOD
Baselines						
LSTM	0.21	0.00	0.99	0.00	0.25	0.07
LSTM-Atten	0.68	0.00	**1.00**	0.00	0.37	0.01
RMC	0.01	0.00	0.99	0.00	0.33	0.01
Transformer	0.97	0.00	0.97	0.00	0.37	0.00
UT	**1.00**	0.00	**1.00**	0.00	**0.62**	0.00
Ours						
S2G-CNN	0.96	**0.99**	0.98	0.53	0.51	0.33
S2G-ACNN	0.90	0.92	0.96	**0.55**	0.44	**0.35**

	#params	Error	#Failed tasks
Baselines[5]			
LSTM	25.6M	24.9 ± 5.8	12.1 ± 3.7
Transformer	0.5M	33.1 ± 1.7	18.9 ± 0.3
UT	0.5M	26.8 ± 6.0	15.0 ± 4.0
TextCNN	0.2M	37.8 ± 0.4	19.0 ± 0.0
Ours			
S2G-TextCNN	0.8M	10.8 ± 0.8	6.0 ± 0.0

Table 3: Error and #Failed tasks (> 5% error) on the bAbI QA 10k joint tasks (for 10 runs).

- Code: https://github.com/segwangkim/neural-seq2grid-module
- Contact: ksk5693@snu.ac.kr