Gating Mechanisms for Combining Character and Word-level Word Representations: An Empirical Study

Jorge A. Balazs, Yutaka Matsuo
The University of Tokyo, Graduate School of Engineering, Japan
{jorge, matsuo}@weblab.t.u-tokyo.ac.jp

東京大学 THE UNIVERSITY OF TOKYO

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Problem

Incorporating subword information into word representations has been shown to be beneficial, however there is no principled way for doing so.

Questions

- How does the method for combining character and word representations affect the quality of final word representations?
- What is effect these have in downstream performance?

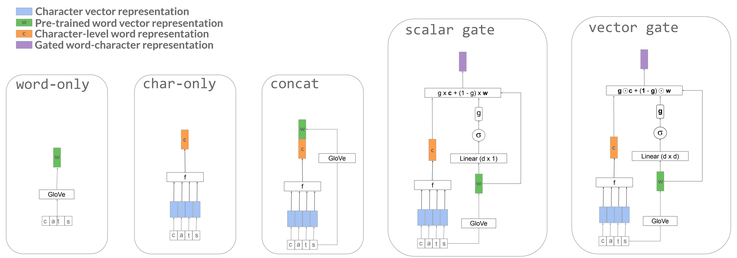
Summary

- A vector gate is the best at combining character and word representations, as measured by word similarity tasks.
- This mechanism learns that to properly model increasingly infrequent words, it has to increasingly rely on character-level information.
- Despite the increased expressivity of word representations it offers, it has no clear effect in sentence representations, as measured by sentence evaluation tasks.

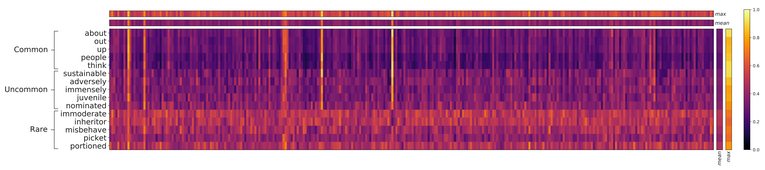
Model Description

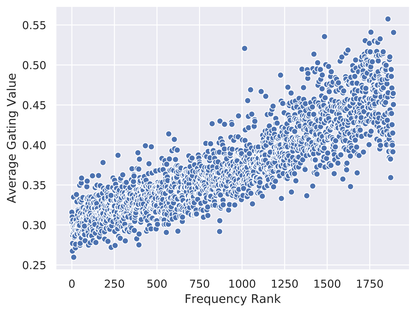
- We initialize word-level word representations $\boldsymbol{v}_i^{(w)}$ with GloVe, and create character-level word representations $\boldsymbol{v}_i^{(c)}$ with a BiLSTM over randomly-initialized character representations.
- We test 5 different ways of combining $\boldsymbol{v}_i^{(w)}$ and $\boldsymbol{v}_i^{(c)}$ into the final word representations $\boldsymbol{v}_i$:
  - **word-only**: $\boldsymbol{v}_i = \boldsymbol{v}_i^{(w)}$
  - **char-only**: $\boldsymbol{v}_i = \boldsymbol{v}_i^{(c)}$
  - **concat**: $\boldsymbol{v}_i = [\boldsymbol{v}_i^{(w)}; \boldsymbol{v}_i^{(c)}]$
  - **scalar gate**:
    $g_i = \sigma(\boldsymbol{w}^\top \boldsymbol{v}_i^{(w)} + b)$
    $\boldsymbol{v}_i = g_i \boldsymbol{v}_i^{(c)} + (1 - g_i) \boldsymbol{v}_i^{(w)}$
  - **vector gate**:
    $\boldsymbol{g}_i = \sigma(\boldsymbol{W} \boldsymbol{v}_i^{(w)} + \boldsymbol{b})$
    $\boldsymbol{v}_i = \boldsymbol{g}_i \odot \boldsymbol{v}_i^{(c)} + (1 - \boldsymbol{g}_i) \odot \boldsymbol{v}_i^{(w)}$
- We feed the final word representations $\boldsymbol{v}_i$ to a BiLSTM, and max-pool its output to obtain a sentence representation.
- Models are trained in the SNLI and MultiNLI (MNLI) datasets. The combined representation of the premise-hypothesis pair is defined as $\boldsymbol{s} = [\boldsymbol{s}_p; \boldsymbol{s}_h; |\boldsymbol{s}_p - \boldsymbol{s}_h|; \boldsymbol{s}_p \odot \boldsymbol{s}_h]$, where $\boldsymbol{s}_p$ is the sentence representation of the premise and $\boldsymbol{s}_h$ that of the hypothesis.
- $\boldsymbol{s}$ is finally mapped to label space through a fully-connected network.

Gating Mechanisms



Gating Values





Word-level Results

		MEN	MTurk287	MTurk771	RG65	RW	SimLex999	SimVerb3500	WS353	WS353R	WS353S
SNLI	w	71.78	35.40	49.05	61.80	18.43	19.17	10.32	39.27	28.01	53.42
	c	9.85	-5.65	0.82	-5.28	17.81	0.86	2.76	-2.20	0.20	-3.87
	cat	71.91	**35.52**	48.84	62.12	18.46	19.10	10.21	39.35	28.16	53.40
	sg	70.49	34.49	46.15	59.75	18.24	17.20	8.73	35.86	23.48	50.83
	vg	**80.00**	32.54	**62.09**	**68.90**	**20.76**	**37.70**	**20.45**	**54.72**	**47.24**	**65.60**
MNLI	w	68.76	50.15	68.81	65.83	18.43	42.21	25.18	61.10	58.21	70.17
	c	4.84	0.06	1.95	-0.06	12.18	3.01	1.52	-4.68	-3.63	-3.65
	cat	68.77	50.40	68.77	65.92	18.35	42.22	25.12	61.15	58.26	70.21
	sg	67.66	49.58	68.29	64.84	18.36	41.81	24.57	60.13	57.09	69.41
	vg	**76.69**	**56.06**	**70.13**	**69.00**	**25.35**	**48.40**	**35.12**	**68.91**	**64.70**	**77.23**

Sentence-level Results

		Classification							Entailment	Relatedness	Semantic Textual Similarity	
		CR	MPQA	MR	SST2	SST5	SUBJ	TREC	SICKE	SICKR†	STS16†	STSB†
SNLI	w	80.50	84.59	74.18	78.86	42.33	**90.38**	**86.83**	86.37	88.52	59.90*	71.29*
	c	74.90*	78.86*	65.93*	69.42*	35.56*	82.97*	83.31*	84.13*	83.89*	59.33*	67.20*
	cat	80.44	84.66	74.31	78.37	41.34*	90.28	85.80*	**86.40**	88.44	59.90*	71.24*
	sg	**80.59**	84.60	**74.49**	**79.04**	41.63*	90.16	86.00	86.10*	**88.57**	60.05*	71.34*
	vg	80.42	**84.66**	74.26	78.87	**42.38**	90.07	85.97	85.67	88.31*	**60.92**	**71.99**
MNLI	w	83.80	**89.13**	79.05	83.38	45.21	91.79	89.23	84.92	86.33	66.08	71.96*
	c	70.23*	72.19*	62.83*	64.55*	32.47*	79.49*	74.74*	81.53*	75.92*	51.47*	61.74*
	cat	**83.96**	89.12	**79.23**	83.70	45.08*	**91.92**	**90.03**	**85.06**	86.45	**66.17**	71.82*
	sg	83.88	89.06	79.22	83.71	45.26	91.66*	88.83*	84.96	86.40	65.49*	71.87*
	vg	83.45*	89.05	79.13	**83.87**	**45.88**	91.55*	89.49	84.82	**86.50**	65.75	**72.82**

Correlations Between Sentence and Word-level Tasks