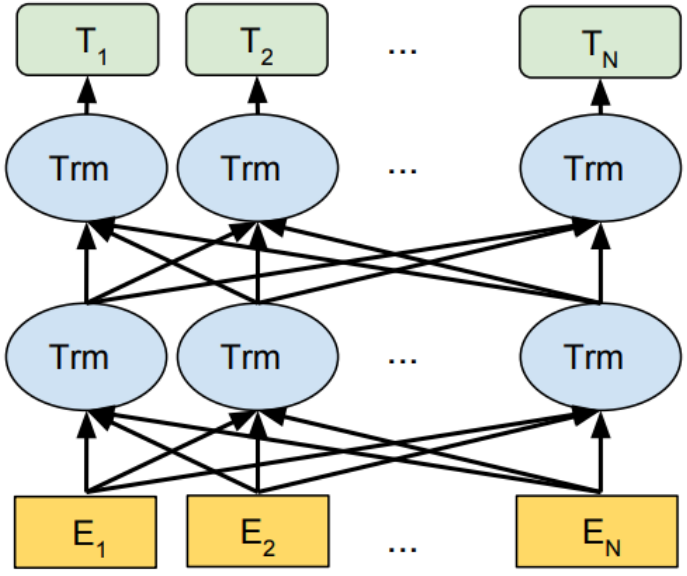
BERT

ARLMs vs. MLM



Learning goals

- Understand the concept of self-supervision
- Gain ability to distinguish different types of language models

AGAIN: WHAT IS A LANGUAGE MODEL?

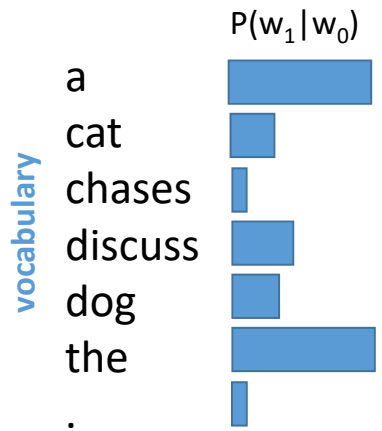
- Statistical model that predicts text that fits well for a given context (typically also text)
- Auto-regressive LMs (ARLMs)
  - Predict one word that is highly likely given a prompt (previous words)
  - For predicting an entire text, repeat the process (i.e., extend the prompt with previously predicted words)
  - To predict a text from scratch, use an extra symbol `<START>` as the initial prompt

ARLM: TOY EXAMPLE

<START>

w_0

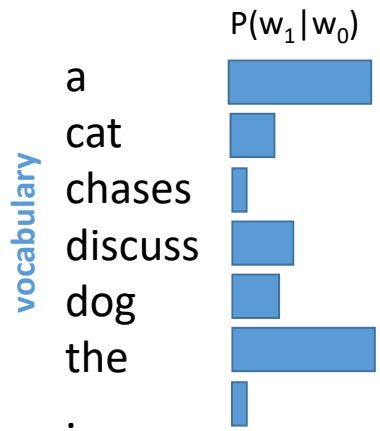
ARLM: TOY EXAMPLE



<START>

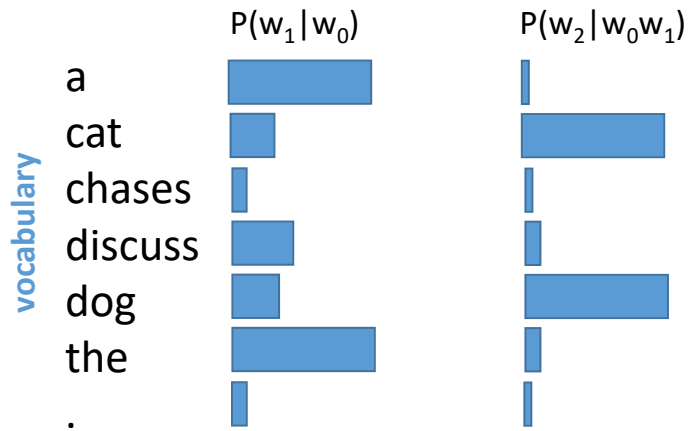
w_0

ARLM: TOY EXAMPLE



<START>	the
w_0	w_1

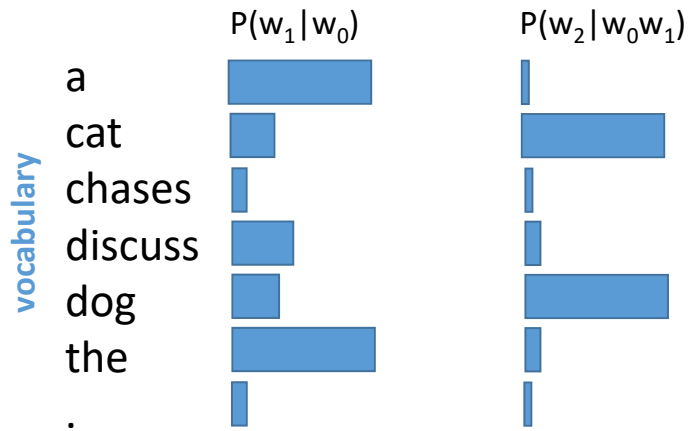
ARLM: TOY EXAMPLE



<START> **the**

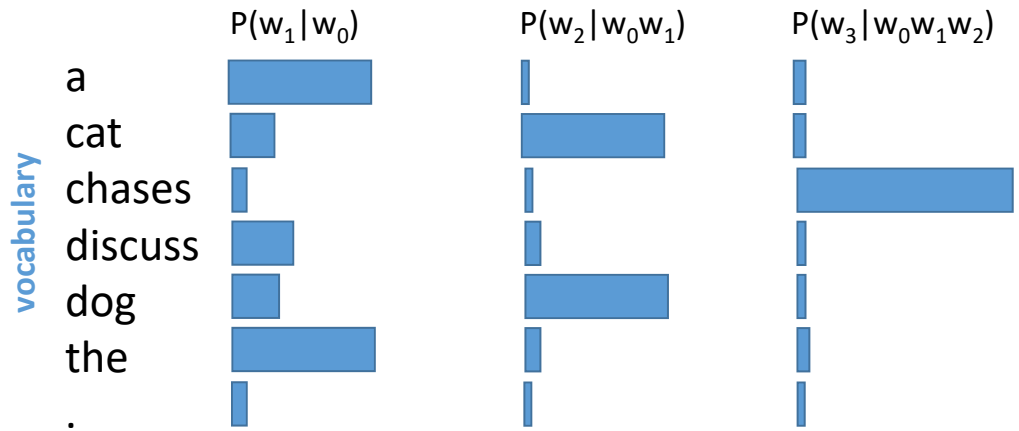
w_0 **w_1**

ARLM: TOY EXAMPLE



<START>	the	dog
w_0	w_1	w_2

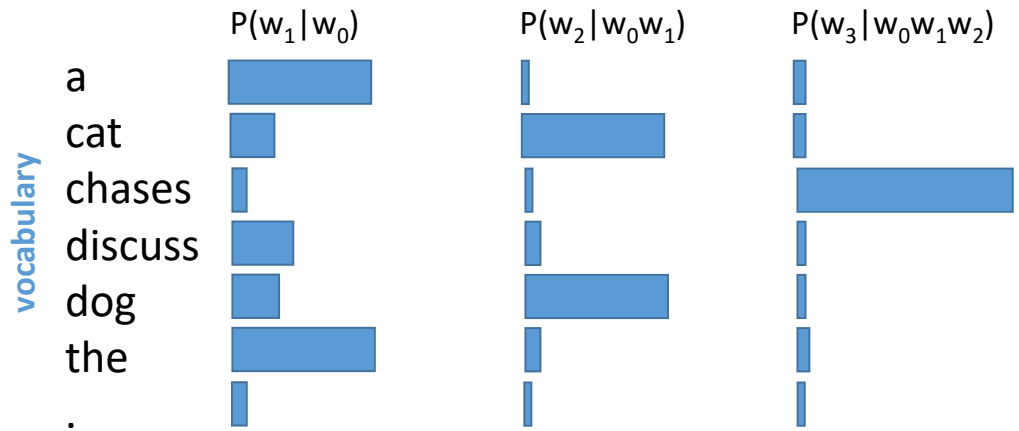
ARLM: TOY EXAMPLE



<START> **the** **dog**

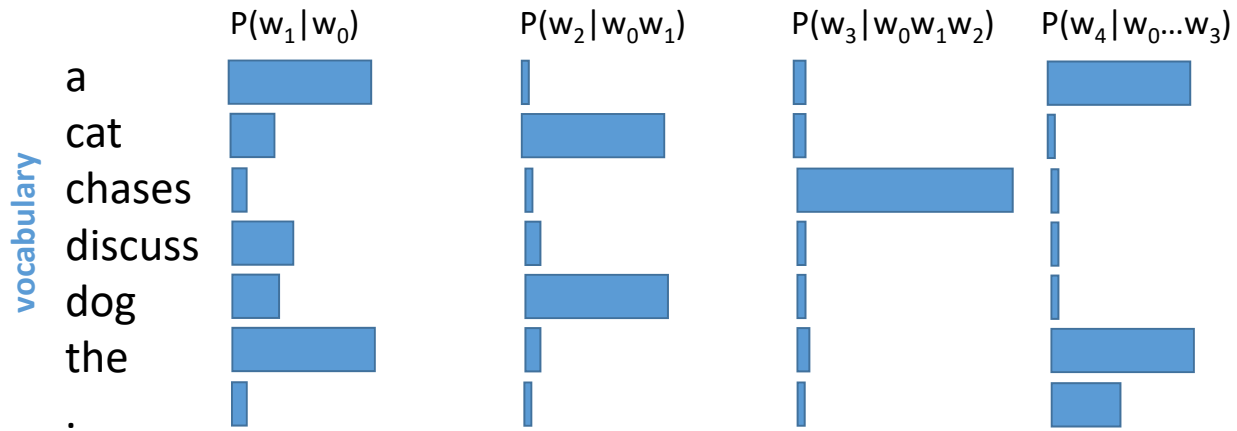
w_0 w_1 w_2

ARLM: TOY EXAMPLE



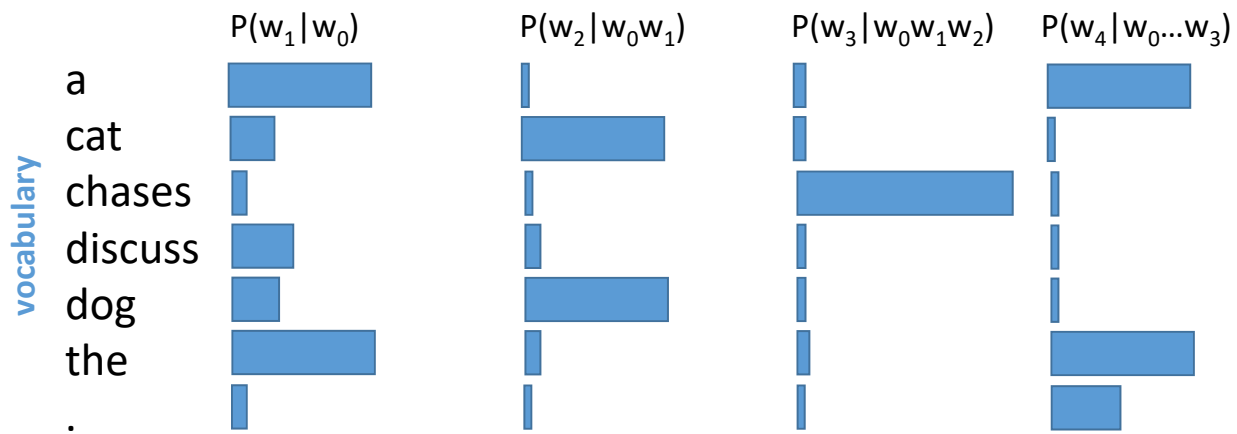
<START>	the	dog	chases
w_0	w_1	w_2	w_3

ARLM: TOY EXAMPLE



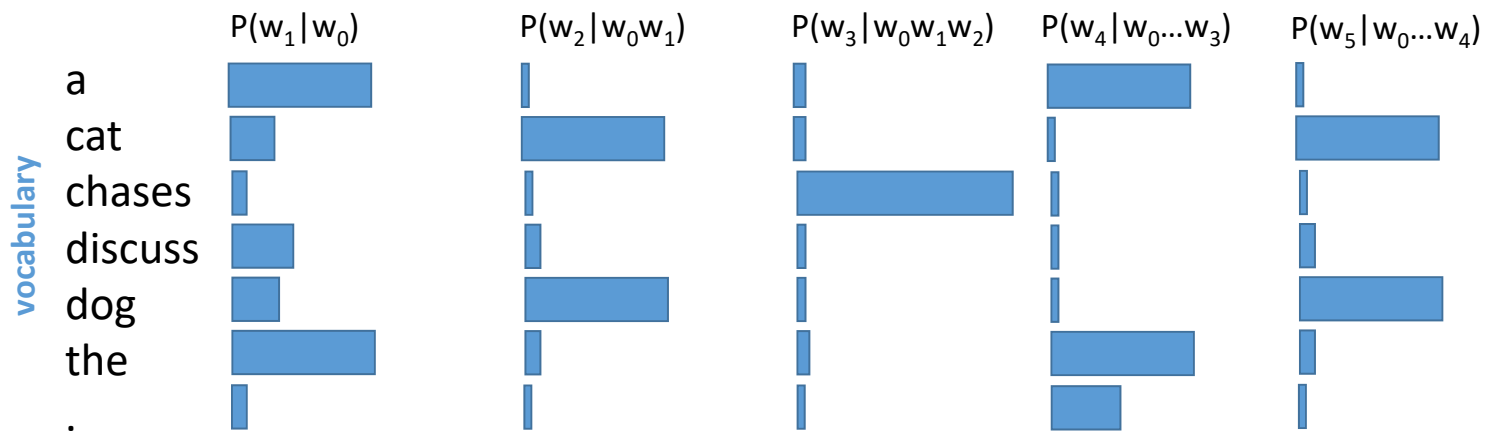
<START>	the	dog	chases
w_0	w_1	w_2	w_3

ARLM: TOY EXAMPLE



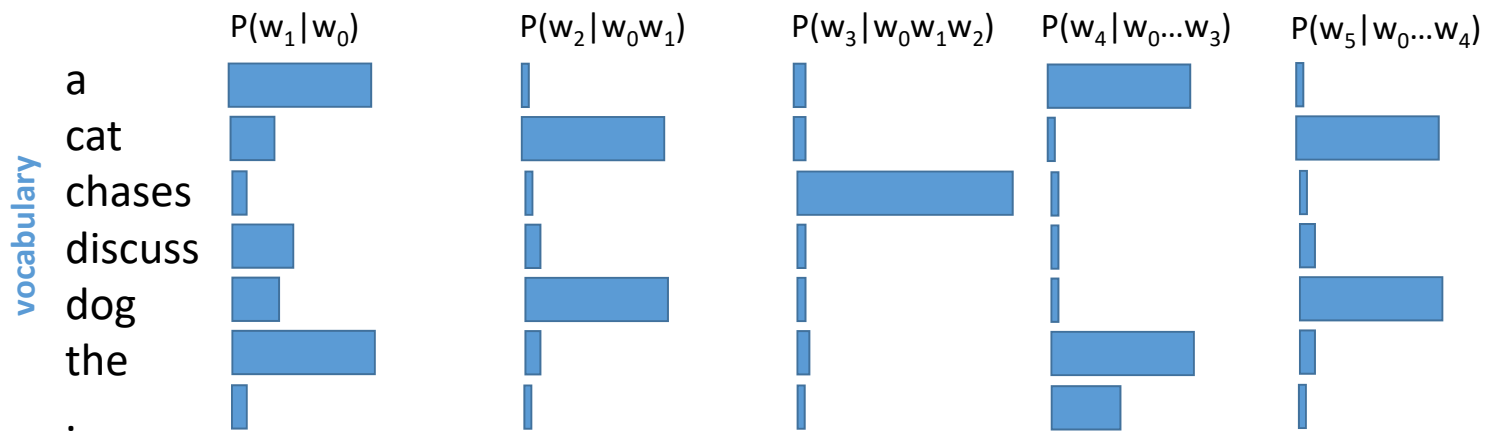
<START>	the	dog	chases	a
w_0	w_1	w_2	w_3	w_4

ARLM: TOY EXAMPLE



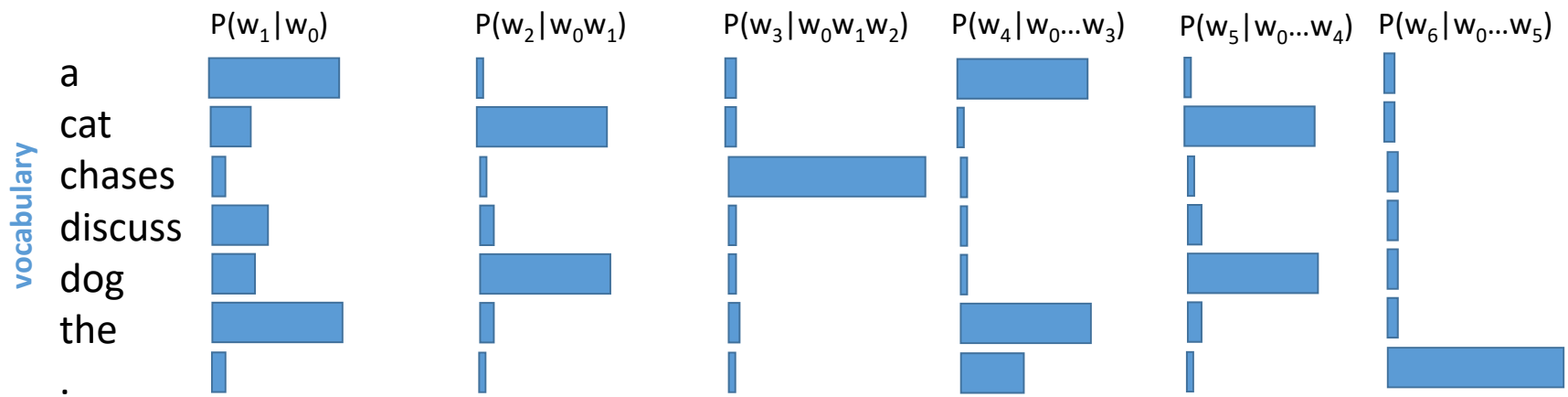
<START>	the	dog	chases	a
w_0	w_1	w_2	w_3	w_4

ARLM: TOY EXAMPLE



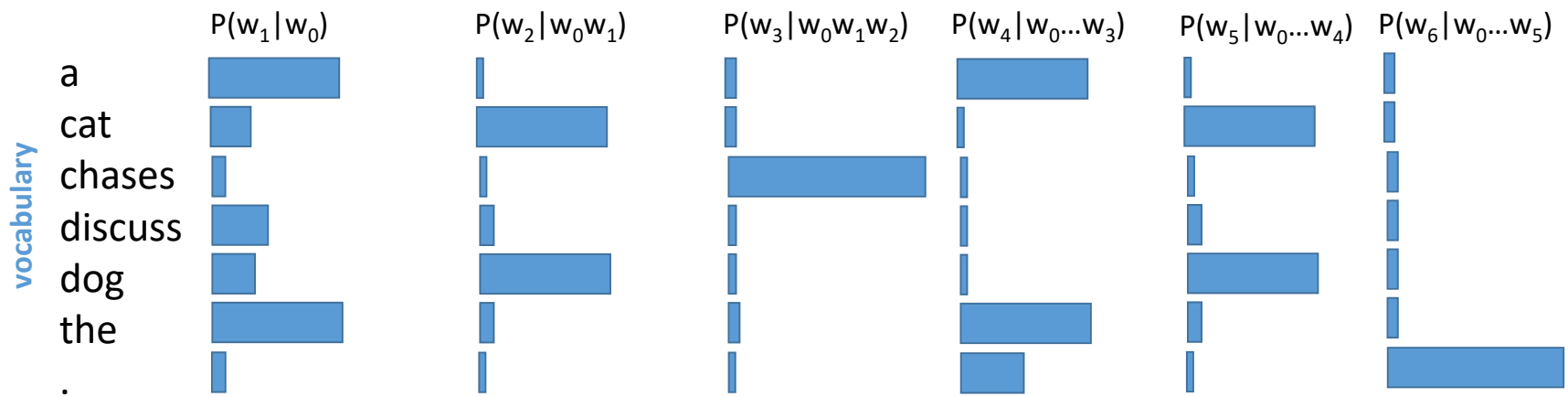
<START>	the	dog	chases	a	cat
w_0	w_1	w_2	w_3	w_4	w_5

ARLM: TOY EXAMPLE



<START>	the	dog	chases	a	cat
w_0	w_1	w_2	w_3	w_4	w_5

ARLM: TOY EXAMPLE



<START>	the	dog	chases	a	cat	.
w_0	w_1	w_2	w_3	w_4	w_5	w_6

ARLM: PROBABILISTIC INTERPRETATION

- Gives an estimate for the probability of a sentence using conditional probabilities
- In general:

$$P(A \cap B) = P(B) \cdot P(A|B)$$

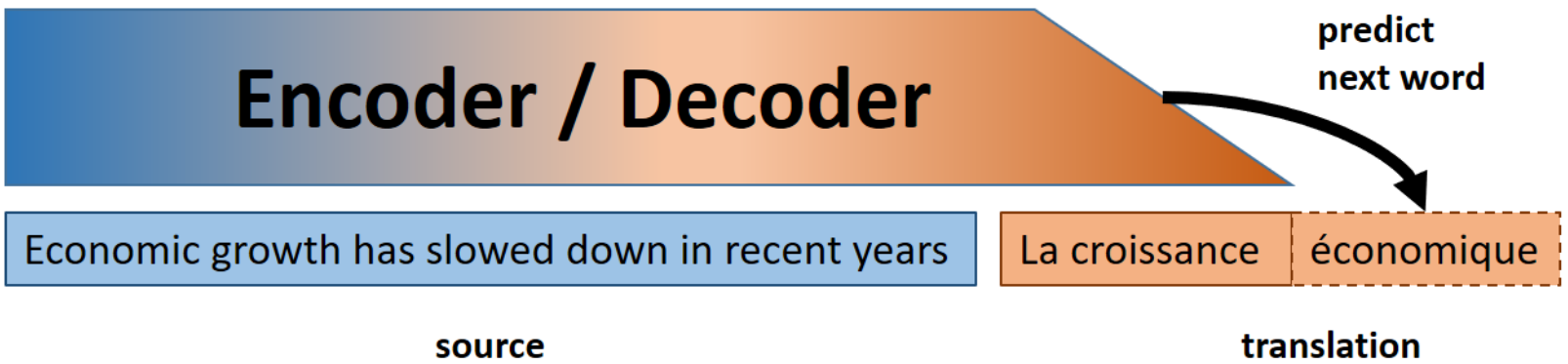
- For $P(sentence)$:

$$P(w_1, w_2, \ldots, w_n | w_0)$$

$$= P(w_1|w_0) \cdot P(w_2|w_0, w_1) \cdot \ldots \cdot P(w_n|w_0, \ldots, w_{n-1})$$

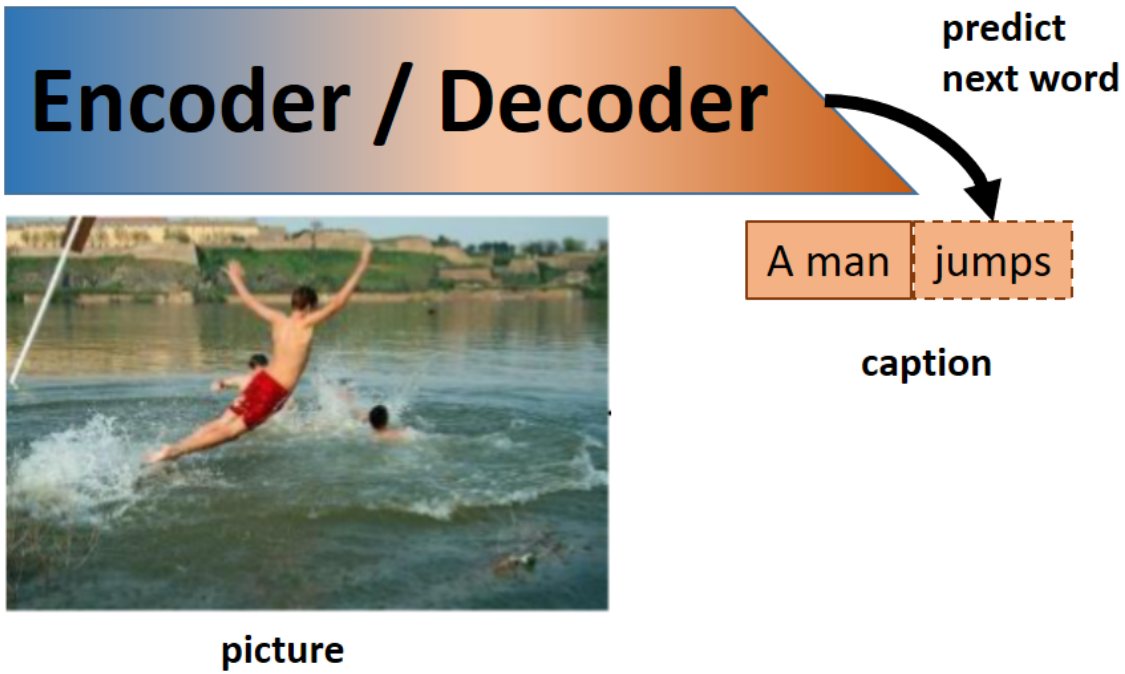
EXAMPLES OF ARLMS (1)

Neural Machine Translation:



EXAMPLES OF ARLMS (1)

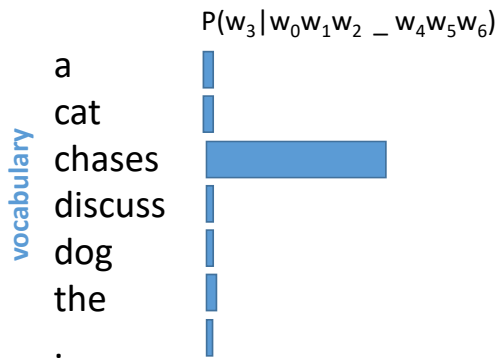
Image Captioning:



MASKED LANGUAGE MODELS (MLM)

- We have seen auto-regressive LMs
  - context: previous words
  - predict: next word
- Another type: *Masked* LMs (MLMs)
  - context: surrounding words
  - predict: masked word

MLM: TOY EXAMPLE



<START>	the	dog	<MASK>	a	cat	.
w_0	w_1	w_2		w_4	w_5	w_6

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MLM: PROBABILISTIC INTERPRETATION

- Estimates $P(w_i|w_0, w_1, w_{i-1}, \ldots, w_{i+1}, w_n)$
- No “clean“ estimate for $P(\textit{sentence})$, as

$$P(w_1, w_2, \ldots, w_n|w_0)$$

$$\neq P(w_1|w_0, w_2, \ldots, w_n) \cdot P(w_2|w_0, w_1, w_3, \ldots, w_n)$$

- ARLMs are better than MLMs for generating texts
- Advantage of MLMs: Learning contextualized representations

SELF-SUPERVISION

DEFINITION

Unsupervised Learning:

- No labels attached to the data
- Learn patterns / clusters from the features only

Supervised Learning:

- (Gold) Labels attached to the data
- Learn from the association between features and labels

Self-Supervised Learning:

- No *external* labels attached to the data
  $\rightarrow$ Samples with suitable labels can be generated from the known structure of the data itself
- *Technically* supervised learning, but *no labeling effort* $+$ simultaneous ability to generate massive amounts of labeled data points

SELF-SUPERVISED OBJECTIVES

Self-supervised objectives:

- Skip-gram objective (cf. word2vec)
- Language modeling objective
- *Masked language modeling (MLM)* objective
- ... and many more possibilities for text data