Modelling monotonic and non-monotonic attribute dependencies with embeddings: A theoretical analysis

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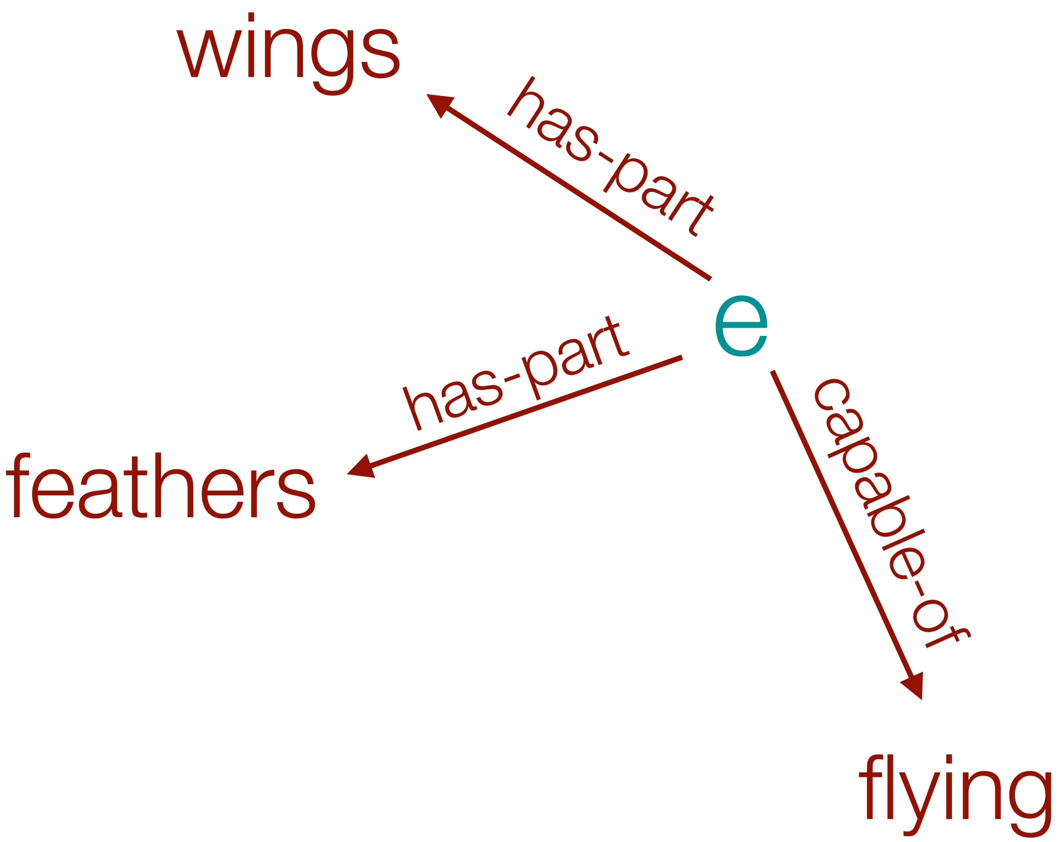
Motivating example



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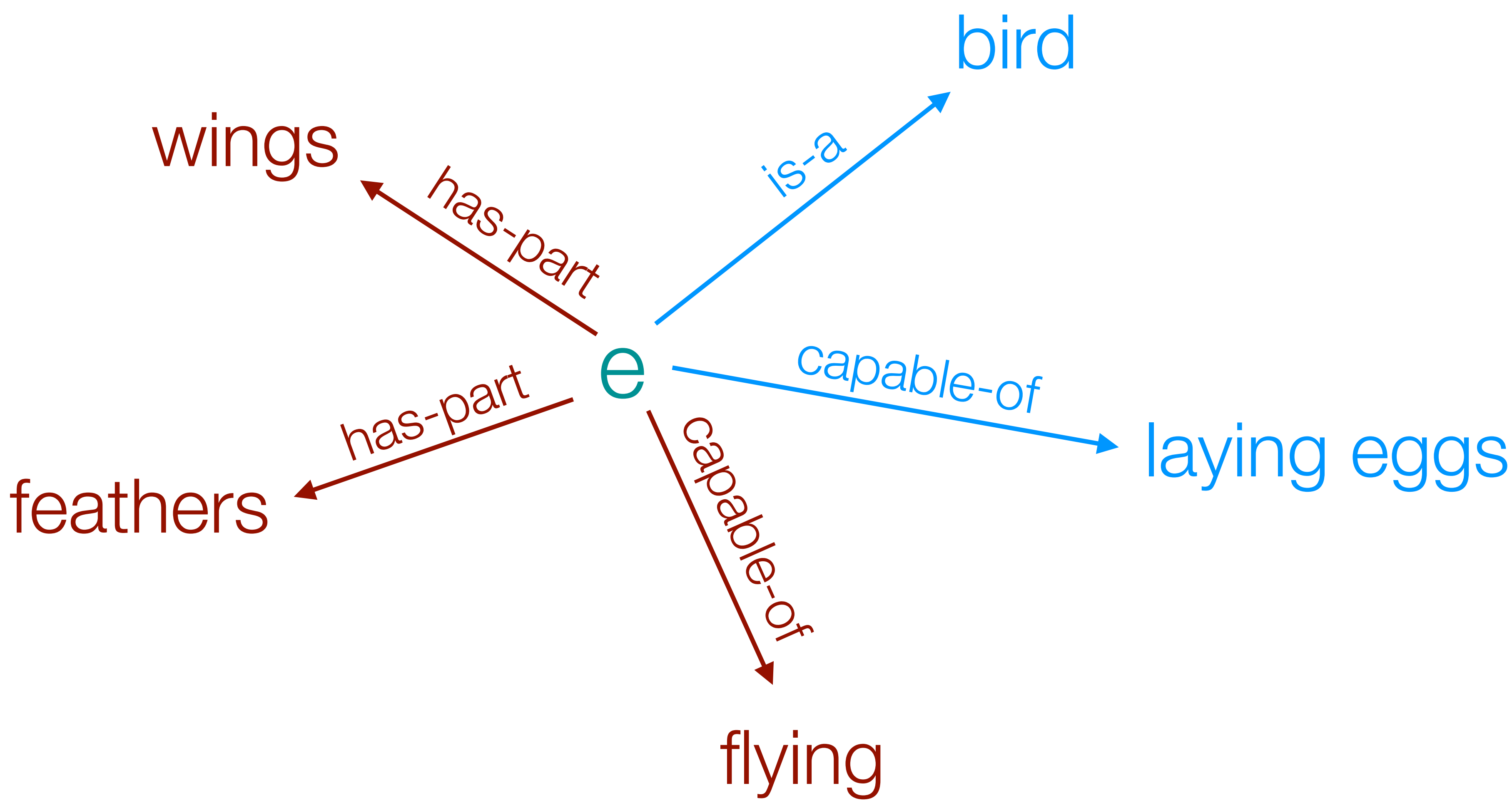

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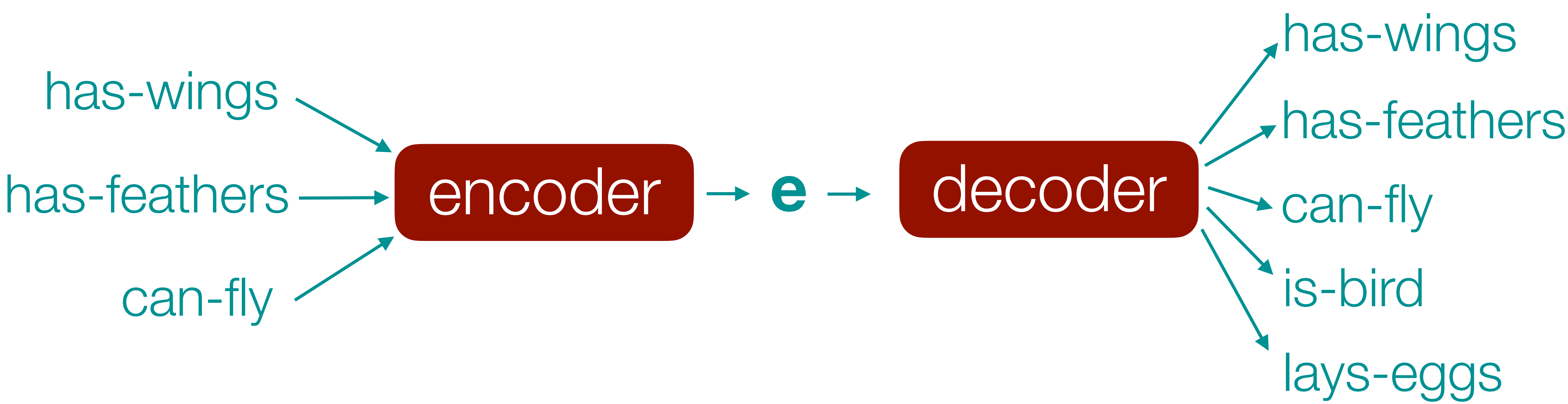
Motivating example



has-wings ∧ has-feathers ∧ can-fly → is-bird

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An encoder-decoder view

$Emb(a_1, ..., a_n)$	$Lab(\mathbf{e})$	**Monotonic**	**Non-mon.**
$\frac{1}{n}\sum_i \mathbf{a_i}$	$\{b \mid \mathbf{e} \cdot \tilde{\mathbf{b}} \geq \lambda_b\}$	✗	✗
$\frac{1}{n}\sum_i \mathbf{a_i}$	$\{b \mid d(\mathbf{e}, \tilde{\mathbf{b}}) \leq \theta_b\}$	✗	✗
$\frac{\sum_i \mathbf{a_i}}{\lVert\sum_i \mathbf{a_i}\rVert}$	$\{b \mid \mathbf{e} \cdot \tilde{\mathbf{b}} \geq \lambda_b\}$	✗	✗
$\frac{\sum_i \mathbf{a_i}}{\lVert\sum_i \mathbf{a_i}\rVert}$	$\{b \mid d(\mathbf{e}, \tilde{\mathbf{b}}) \leq \theta_b\}$	✗	✗
$\arg\max_{\mathbf{e}} \sum_i \log\sigma(\mathbf{e} \cdot \mathbf{a_i}) + \kappa\lVert\mathbf{e}\rVert^2$	$\{b \mid \mathbf{e} \cdot \tilde{\mathbf{b}} \geq \lambda_b\}$	✗	✗
$\arg\max_{\mathbf{e}} \sum_i \log\sigma(\mathbf{e} \cdot \mathbf{a_i}) + \kappa\lVert\mathbf{e}\rVert^2$	$\{b \mid d(\mathbf{e}, \tilde{\mathbf{b}}) \leq \theta_b\}$	✗	✗
$\frac{1}{n}\sum_i \mathbf{a_i}$	$\{b \mid \text{ReLU}(\mathbf{e}) \cdot \mathbf{b} \geq 0\}$	✓	✓
$\mathbf{a_1} \odot ... \odot \mathbf{a_n}$	$\{b \mid \mathbf{e} \cdot \tilde{\mathbf{b}} \geq 0\}$	✓	✓
$\mathbf{a_1} \odot ... \odot \mathbf{a_n}$	$\{b \mid \mathbf{e} \cdot \mathbf{b} \geq 0\}$	✗	✗
$\max(\mathbf{a_1}, ..., \mathbf{a_n})$	$\{b \mid \mathbf{b} \preceq \mathbf{e}\}$	✓	✗

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