

Contrastive Language-Entity Pre-training for Richer Knowledge Graph Embedding

Andrea Papaluca, Daniel Krefl, Artem Lensky, Hanna Suominen



The CLEP Architecture

(Barack Obama, born_in, Honolulu)

A Forward Pass

e^{head} : head node of the relational triplet

d^{tail} : description of the tail node

Batch of KG triplets

$$\{(e_1^{head}, r_1, d_1^{tail}), \dots, (e_n^{head}, r_n, d_n^{tail})\}$$

A Forward Pass

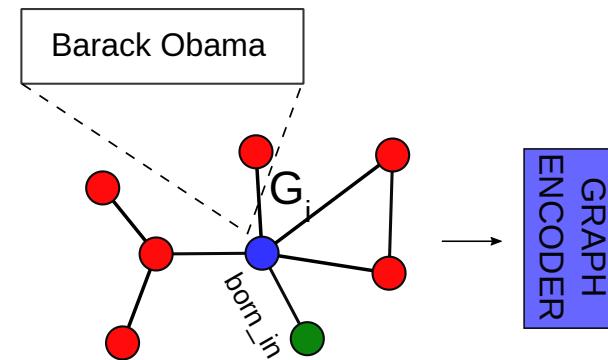
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$$(h_i^{(g)}, \rho_i^{(g)}) = \text{GraphEncoder}(e_i^{head}, r_i)$$



A Forward Pass

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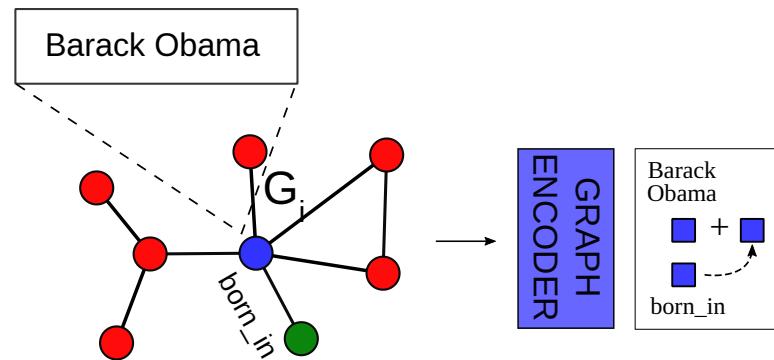
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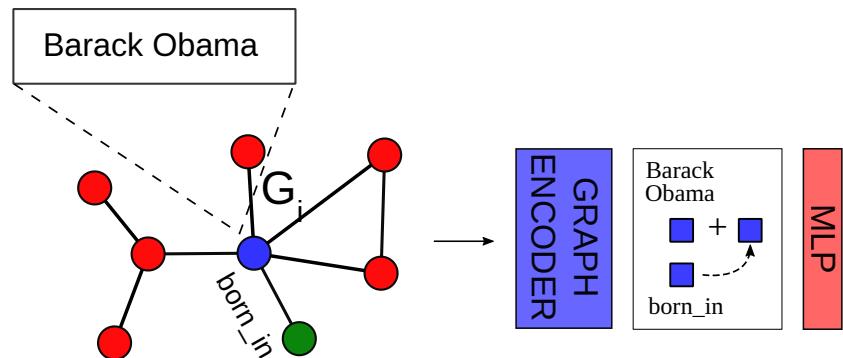
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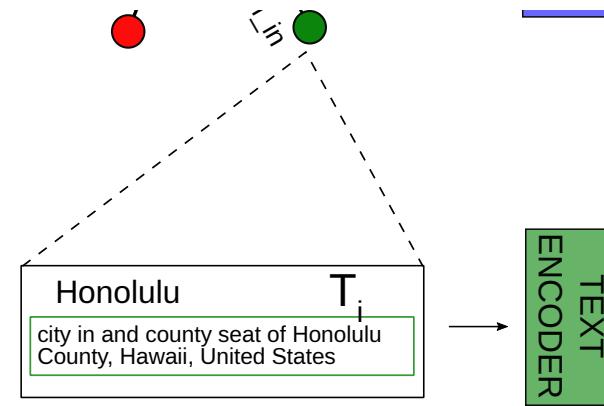
$$x_i^{(g)} = h_i^{(g)} + \rho_i^{(g)}$$

$$\tilde{x}_i^{(g)} = \text{MLP}_g(x_i^{(g)})$$



A Forward Pass

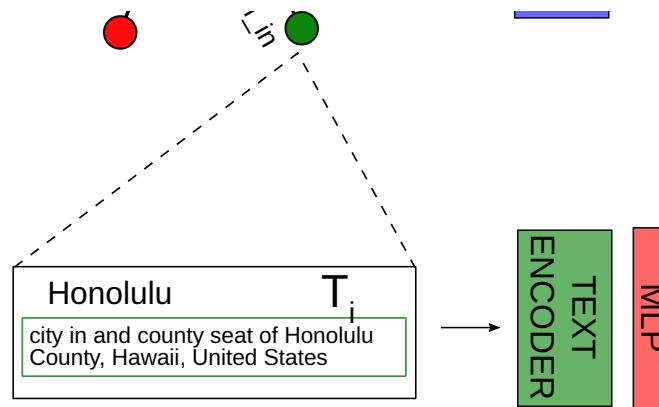
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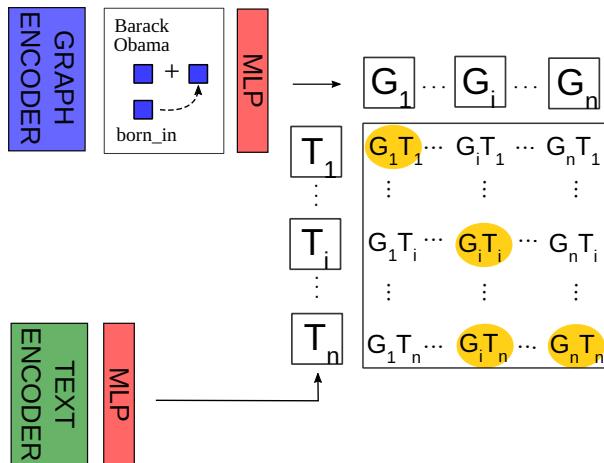
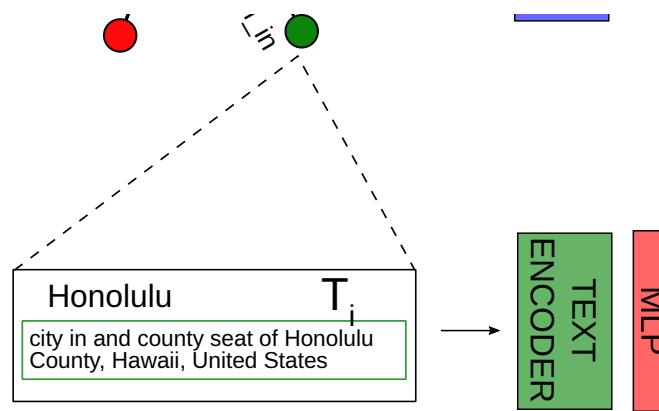
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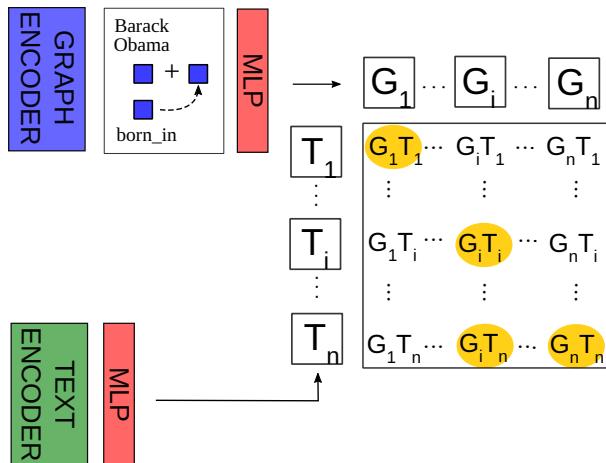
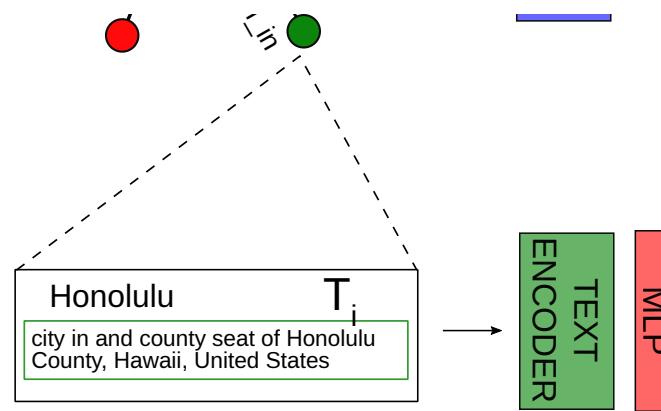
Cosine similarity matrix

$$m_{i,j} = \frac{\tilde{x}_i^{(g)} \cdot \tilde{x}_j^{(t)}}{\|\tilde{x}_i^{(g)}\| \|\tilde{x}_j^{(t)}\|} \cdot e^{\tau}$$

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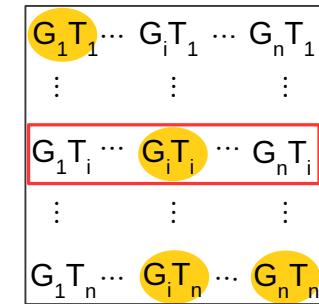
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τ : temperature scaling the logits

A Forward Pass

Row-wise Cross Entropy (CE)

$$\text{CE}(M) = -\frac{1}{n} \sum_{i=1}^n \log \frac{e^{m_{i,i}}}{\sum_{j=1}^n e^{m_{i,j}}}$$



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$G_1 T_1$	\dots	$G_i T_1$	\dots	$G_n T_1$
\vdots		\vdots		\vdots
$G_1 T_i$	\dots	$G_i T_i$	\dots	$G_n T_i$
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$$\mathcal{L} = \frac{1}{2} \left(\text{CE}(M) + \text{CE}(M^\top) \right)$$

→ Enforces minimization of incorrect entity-description associations simultaneously in rows and columns!

The aligned Text-Graph space

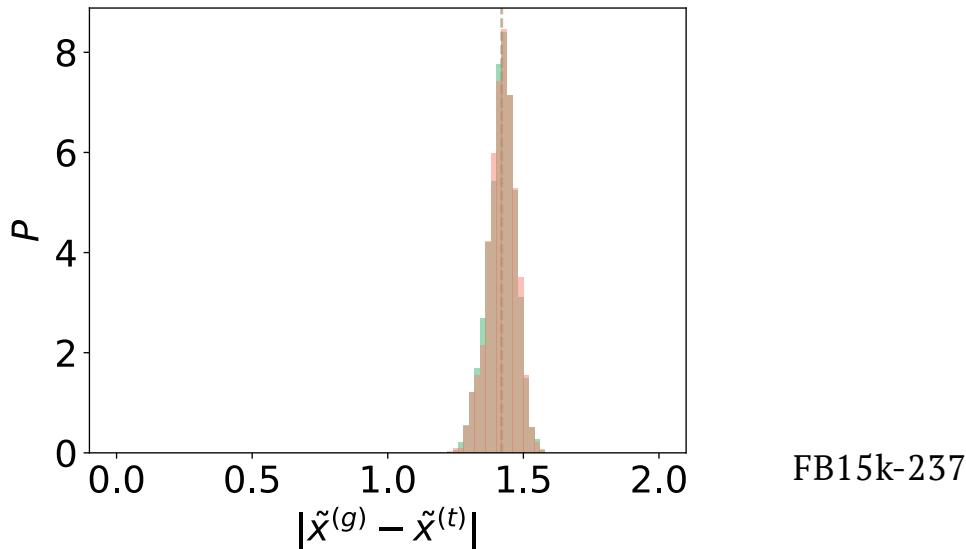
Euclidean distance of the correct/incorrect entity-description associations

$$P\left(\|\tilde{x}_i^{(g)} - \tilde{x}_i^{(t)}\|\right) \quad P\left(\|\tilde{x}_i^{(g)} - \tilde{x}_j^{(t)}\|_{i \neq j}\right)$$

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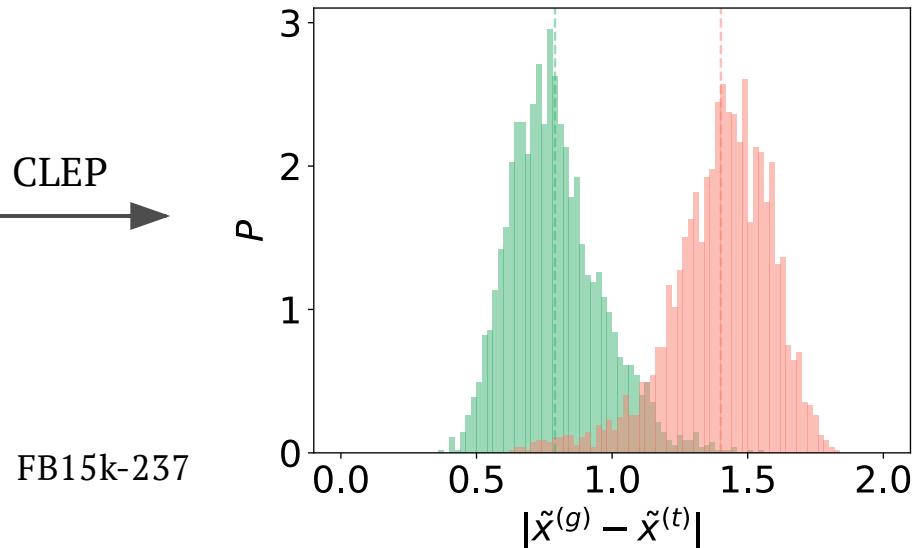
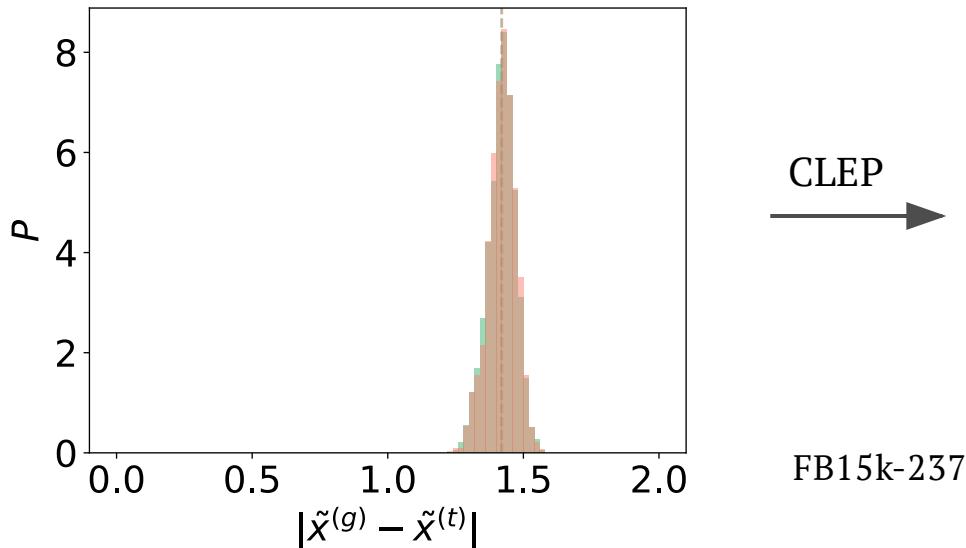
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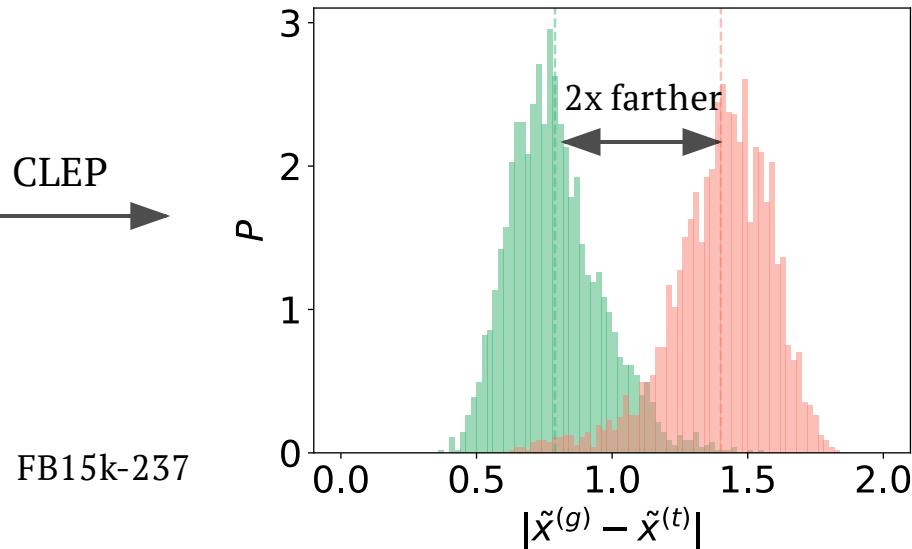
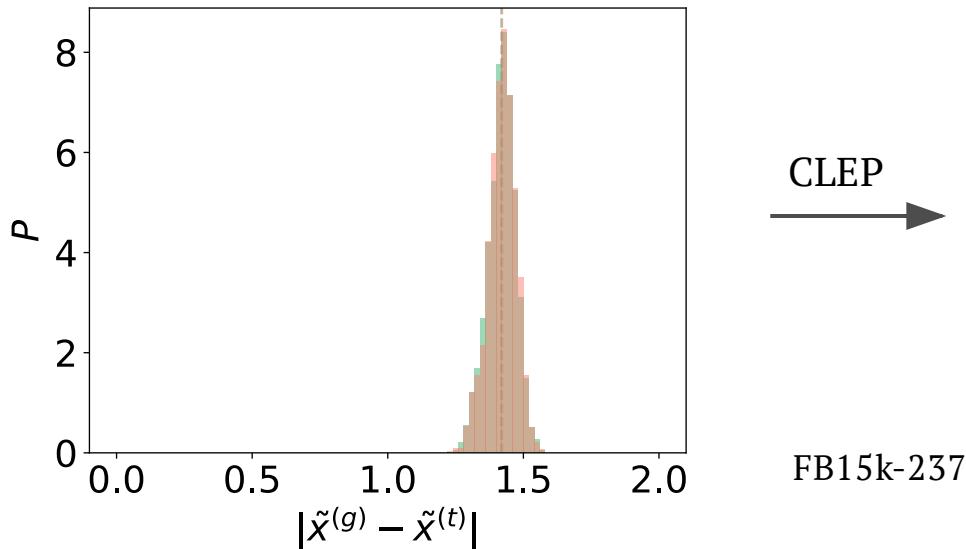
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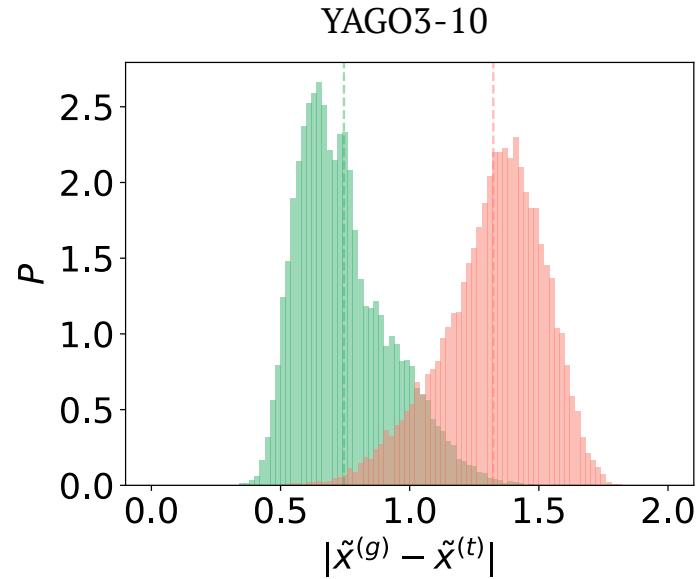
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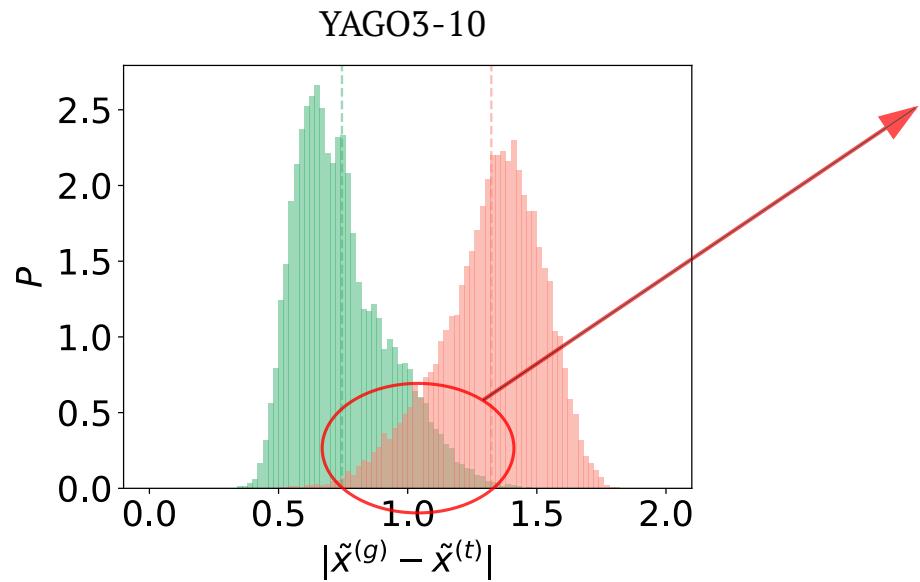
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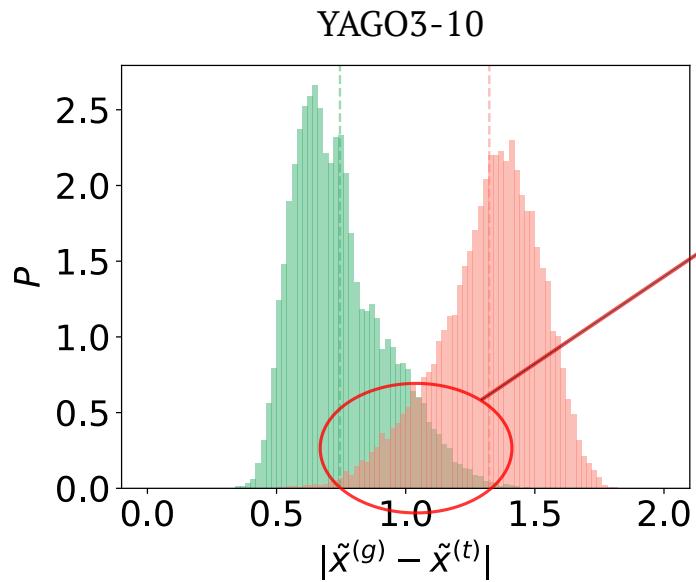
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Incorrect pairs closer than correct ones

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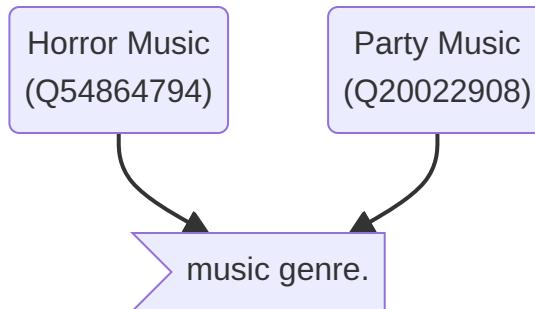
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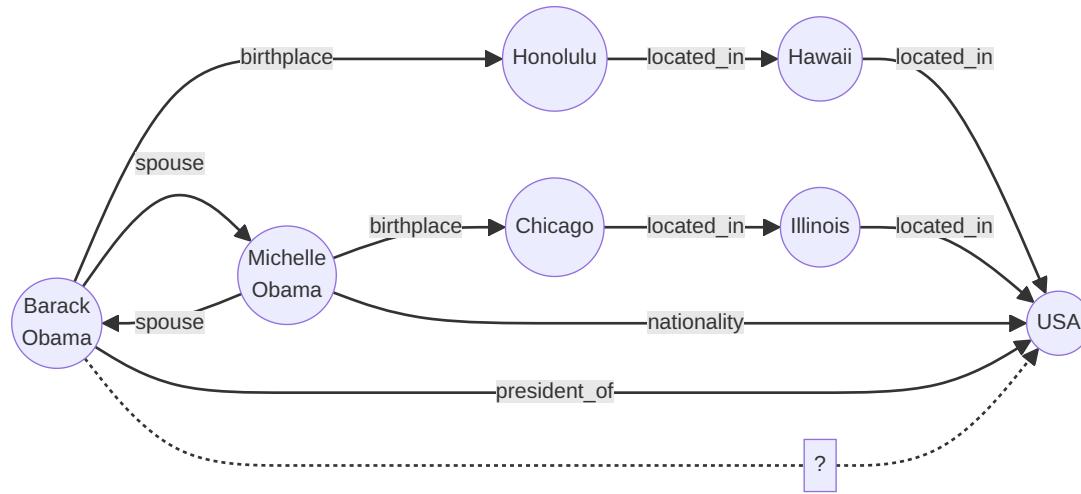
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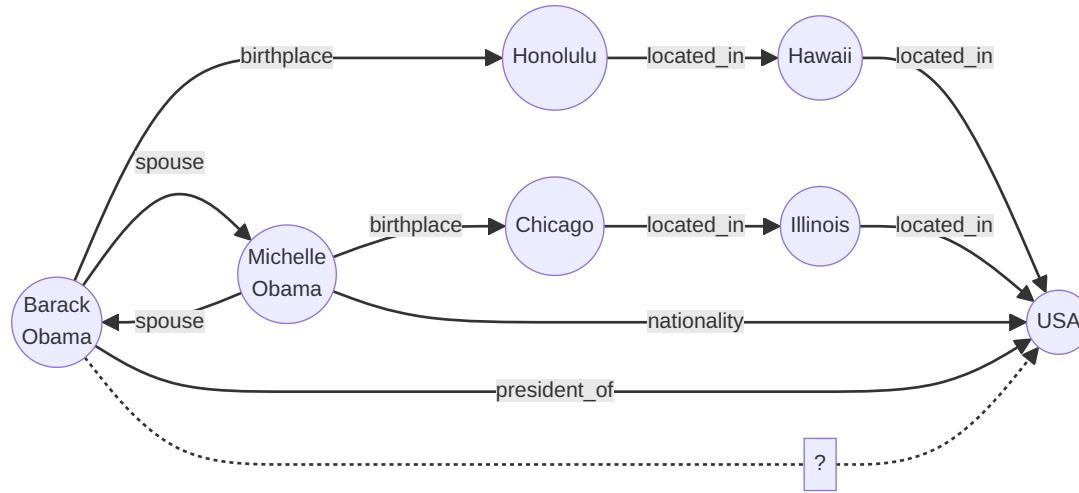
Many descriptions are shared over different entities



Link Prediction across spaces



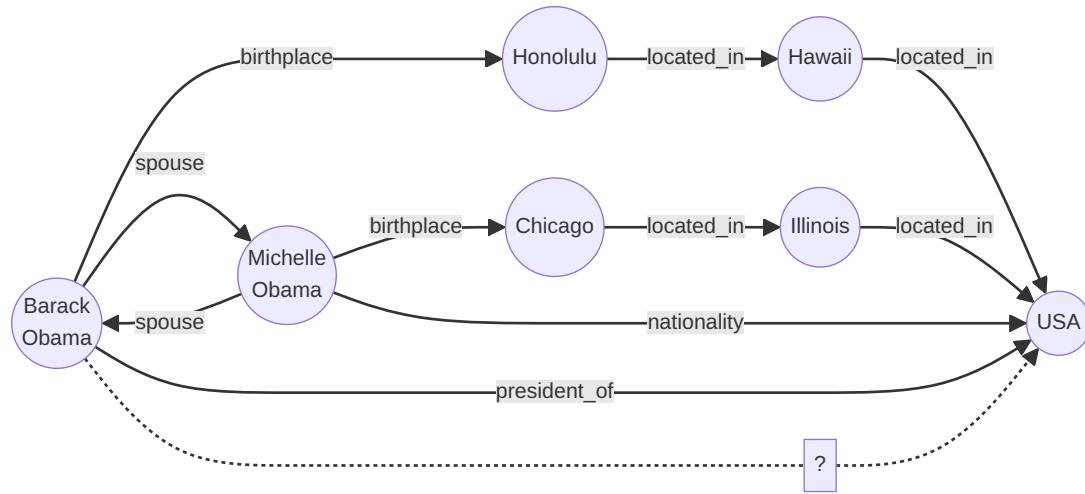
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What's Barack Obama's Nationality?

$$f_s(\text{Barack Obama}, \text{nationality}, v) \quad \forall v \in \mathcal{G}$$

Link Prediction across spaces



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Rank	f_s	Link
1	0.91	(Barack Obama, nationality, USA)
2	0.53	(Barack Obama, nationality, Hawaii)
3	0.44	(Barack Obama, nationality, Illinois)
.	.	.
.	.	.
.	.	.
n	0.11	(Barack Obama, nationality, Michelle Obama)

Link Prediction across spaces

- CLEP is trained to align head entities with tails descriptions $e^{head} + r \sim d^{tail}$

$$f_s(\text{Barack Obama}, \text{ nationality}, d(v)) \quad \forall v \in \mathcal{G}$$

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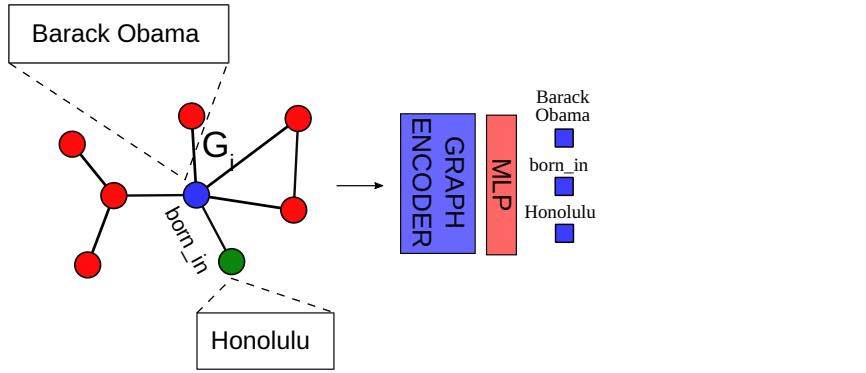
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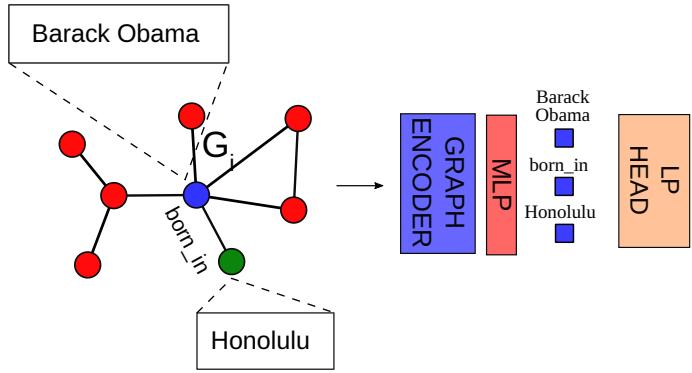
	MR	MRR	hits@1	hits@10
CompGCN _{CLEP}	198	0.222	0.137	0.396
RGCN + Distmult	315	0.237	0.156	0.407

FB15k-237

Link Prediction Finetuning

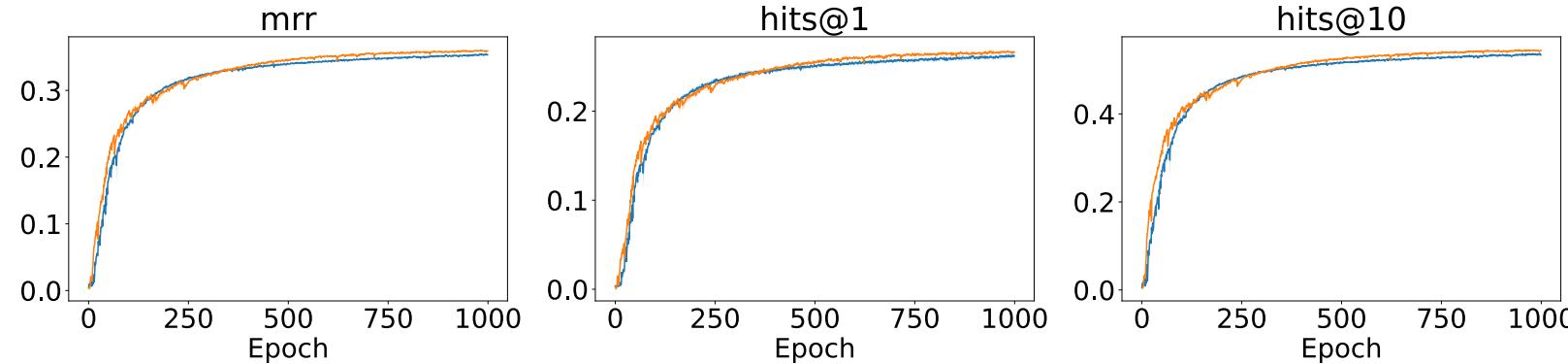


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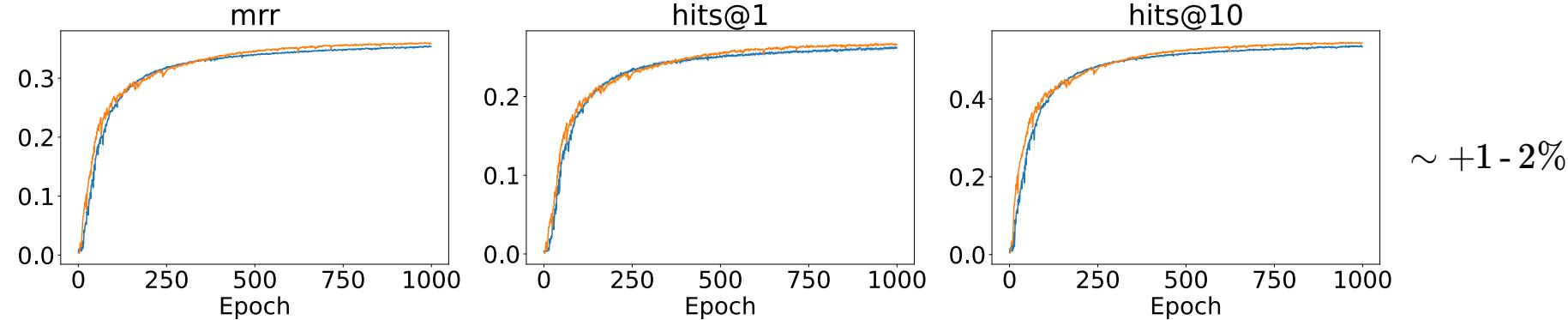
FB15k-237



- Randomly initialized model
- CLEP pretrained model

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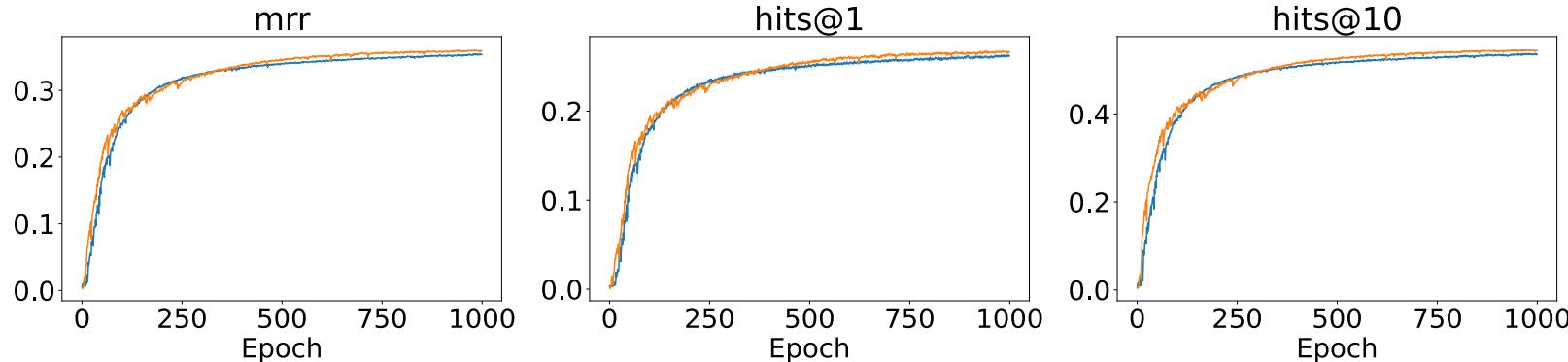
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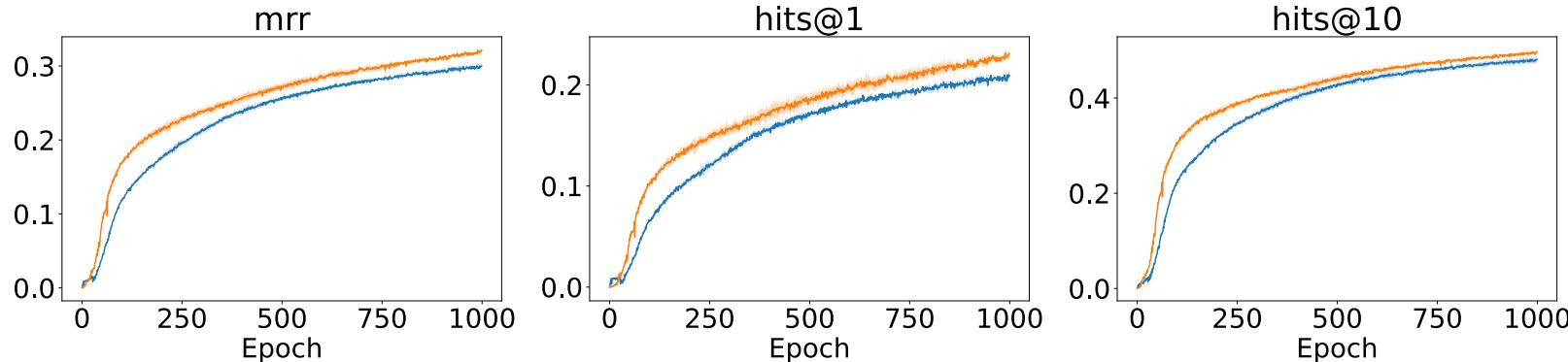
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FB15k-237



$\sim +1 - 2\%$

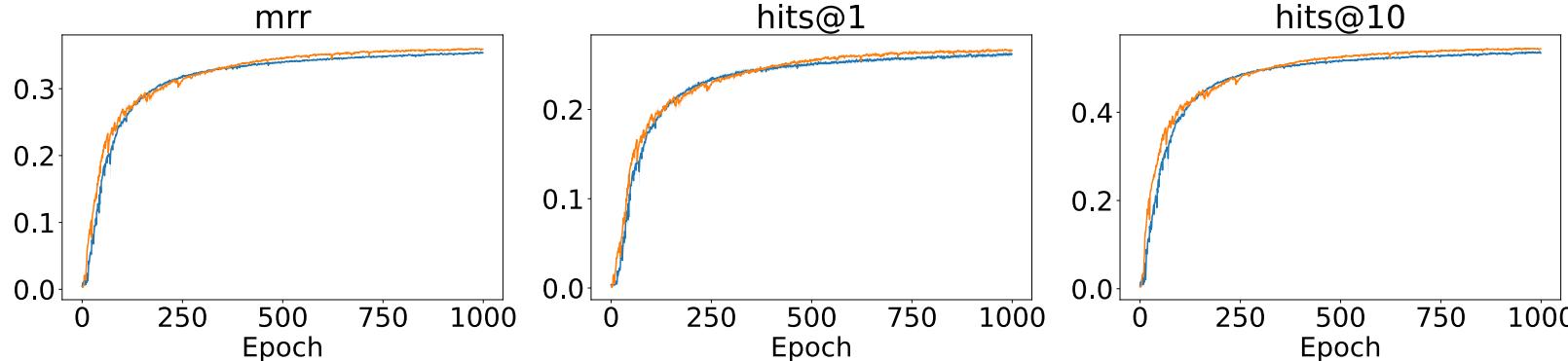
YAGO3-10



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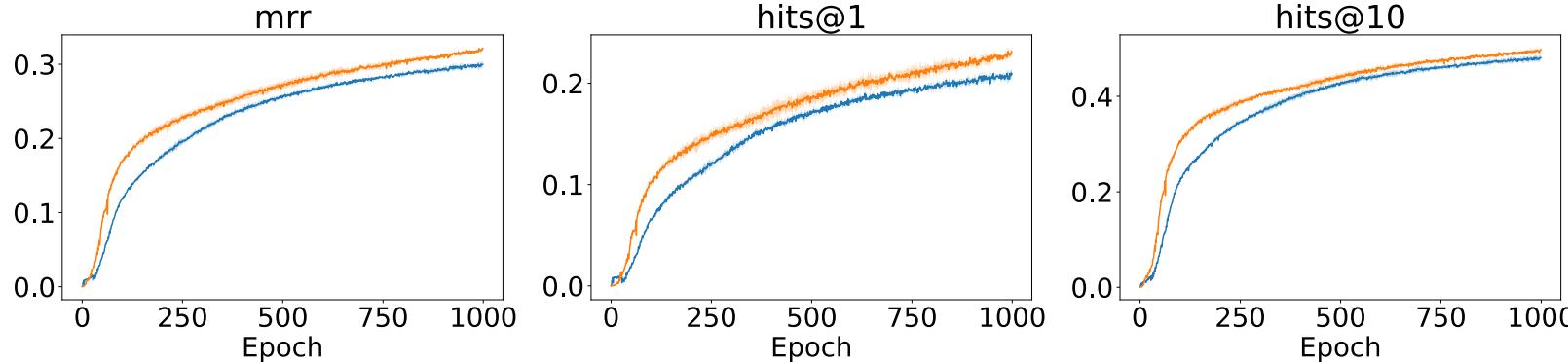
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FB15k-237



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YAGO3-10



$\sim +4 - 10\%$

What is Slidev?

Slidev is a slides maker and presenter designed for developers, consist of the following features

-  **Text-based** - focus on the content with Markdown, and then style them later
-  **Themable** - theme can be shared and used with npm packages
-  **Developer Friendly** - code highlighting, live coding with autocompletion
-  **Interactive** - embedding Vue components to enhance your expressions
-  **Recording** - built-in recording and camera view
-  **Portable** - export into PDF, PPTX, PNGs, or even a hostable SPA
-  **Hackable** - anything possible on a webpage

Read more about [Why Slidev?](#)

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Hover on the bottom-left corner to see the navigation's controls panel, [learn more](#)

Keyboard Shortcuts

`right` / `space`

next animation or slide

`left` / `shift space`

previous animation or slide

`up`

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Here!



Table of contents

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```
<Toc minDepth="1" maxDepth="1"></Toc>
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The title will be inferred from your slide content, or you can override it with `title` and `level` in your frontmatter.

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10. [Link Prediction Finetuning](#)
11. [Link Prediction Finetuning](#)
12. [What is Slidev?](#)
 1. [Navigation](#)
13. [Table of contents](#)
14. [Code](#)

Code

Use code snippets and get the highlighting directly, and even types hover!^[1]

```
// TwoSlash enables TypeScript hover information
// and errors in markdown code blocks
// More at https://shiki.style/packages/twoslash

import { computed, ref } from 'vue'

const count = ref(0)
const doubled = computed(() => count.value * 2)

doubled.value = 2
Cannot assign to 'value' because it is a read-only

// Inside ./snippets/external.ts
export function emptyArray<T>(length: number) {
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Shiki Magic Move

Powered by shiki-magic-move, Slidev supports animations across multiple code snippets.

Add multiple code blocks and wrap them with ````md magic-move` (four backticks) to enable the magic move. For example:

```
1 // step 1
2 const author = reactive({
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4   books: [
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12      }
13    }
14  }
15 }
```

Shiki Magic Move

Powered by shiki-magic-move, Slidev supports animations across multiple code snippets.

Add multiple code blocks and wrap them with ````md magic-move` (four backticks) to enable the magic move. For example:

```
1 // step 3
2 export default {
3   data: () => ({
4     author: {
5       name: 'John Doe',
6       books: [
7         'Vue 2 - Advanced Guide',
8         'Vue 3 - Basic Guide',
9         'Vue 4 - The Mystery'
10        ]
11      }
12    })
13 }
```

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Add multiple code blocks and wrap them with ````md magic-move` (four backticks) to enable the magic move. For example:

```
1 <!-- step 4 -->
2 <script setup>
3 const author = {
4   name: 'John Doe',
5   books: [
6     'Vue 2 - Advanced Guide',
7     'Vue 3 - Basic Guide',
8     'Vue 4 - The Mystery'
9   ]
10 }
11 </script>
```

Components

You can use Vue components directly inside your slides.

```
<Tweet id="1390115482657726468" />
```

We have provided a few built-in components like `<Tweet/>` and `<Youtube/>` that you can use directly. And adding your custom components is also super easy.

```
<Counter :count="10" />
```

-	10	+
---	----	---

Check out the guides for more.

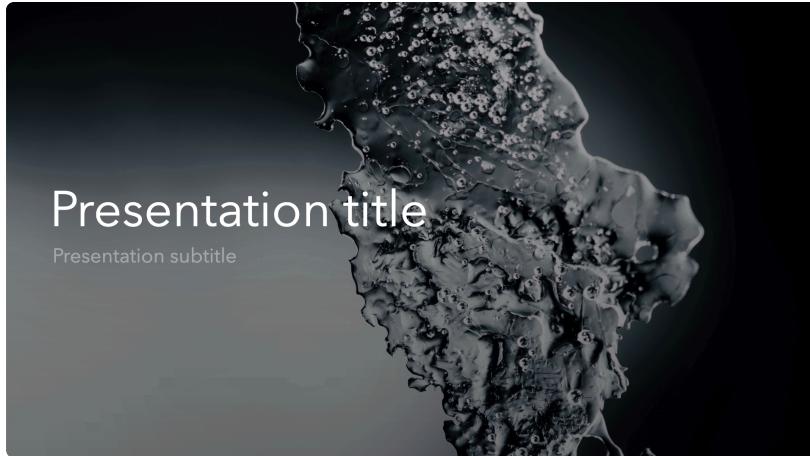
Themes

Slidev comes with powerful theming support. Themes can provide styles, layouts, components, or even configurations for tools. Switching between themes by just **one edit** in your frontmatter:

```
---
```

theme: default

```
--
```



```
---
```

theme: serif

```
--
```



Read more about [How to use a theme](#) and check out the [Awesome Themes Gallery](#).

Clicks Animations

You can add `v-click` to elements to add a click animation.

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This shows up when you click the slide:

```
<div v-click>This shows up when you click the slide.</div>
```

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```

The `v-mark` directive also allows you to add inline marks , powered by Rough Notation:

```
<span v-mark.underline.orange>inline markers</span>
```

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[Learn More](#)

Clicks Animations

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The `v-mark` directive also allows you to add inline marks, powered by Rough Notation:

```
<span v-mark.underline.orange>inline markers</span>
```

[Learn More](#)

Motions

Motion animations are powered by [@vueuse/motion](#), triggered by `v-motion` directive.

```
<div  
  v-motion  
  :initial="{ x: -80 }"  
  :enter="{ x: 0 }"  
  :click-3="{ x: 80 }"  
  :leave="{ x: 1000 }"  
>  
  Slidēv  
</div>
```



Slidēv

[Learn More](#)

LaTeX

LaTeX is supported out-of-box powered by [KaTeX](#).

Inline $\sqrt{3x - 1} + (1 + x)^2$

Block

$$\begin{aligned}\nabla \times \vec{\mathbf{B}} - \frac{1}{c} \frac{\partial \vec{\mathbf{E}}}{\partial t} &= \frac{4\pi}{c} \vec{\mathbf{j}} \nabla \cdot \vec{\mathbf{E}} &= 4\pi\rho \\ \nabla \times \vec{\mathbf{E}} + \frac{1}{c} \frac{\partial \vec{\mathbf{B}}}{\partial t} &= \vec{0} \\ \nabla \cdot \vec{\mathbf{B}} &= 0\end{aligned}$$

[Learn more](#)

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Block

$$\begin{aligned}\nabla \times \vec{\mathbf{B}} - \frac{1}{c} \frac{\partial \vec{\mathbf{E}}}{\partial t} &= \frac{4\pi}{c} \vec{\mathbf{j}} \nabla \cdot \vec{\mathbf{E}} = 4\pi\rho \\ \nabla \times \vec{\mathbf{E}} + \frac{1}{c} \frac{\partial \vec{\mathbf{B}}}{\partial t} &= \vec{\mathbf{0}} \\ \nabla \cdot \vec{\mathbf{B}} &= 0\end{aligned}$$

[Learn more](#)

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Inline $\sqrt{3x - 1} + (1 + x)^2$

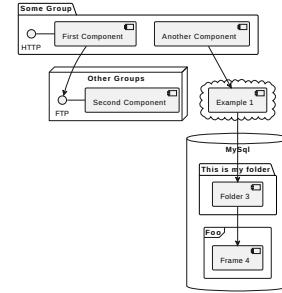
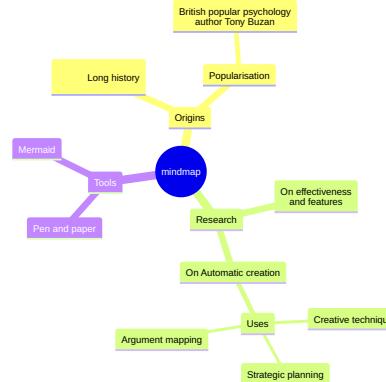
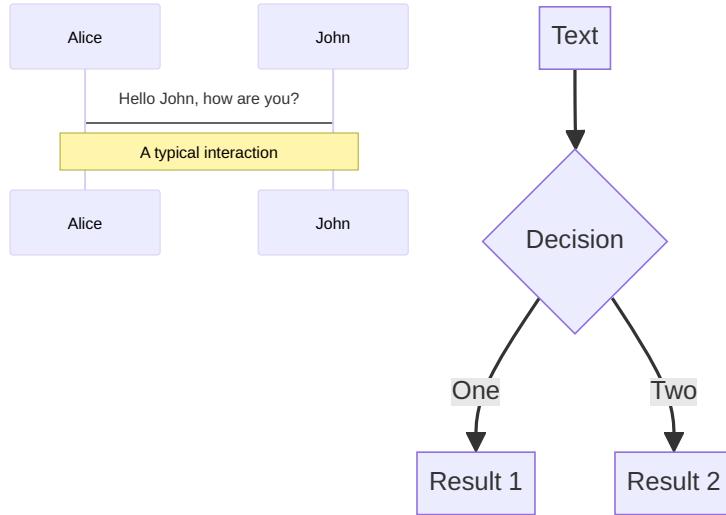
Block

$$\begin{aligned}\nabla \times \vec{\mathbf{B}} - \frac{1}{c} \frac{\partial \vec{\mathbf{E}}}{\partial t} &= \frac{4\pi}{c} \vec{\mathbf{j}} \nabla \cdot \vec{\mathbf{E}} &= 4\pi\rho \\ \nabla \times \vec{\mathbf{E}} + \frac{1}{c} \frac{\partial \vec{\mathbf{B}}}{\partial t} &= \vec{\mathbf{0}} \\ \nabla \cdot \vec{\mathbf{B}} &= 0\end{aligned}$$

[Learn more](#)

Diagrams

You can create diagrams / graphs from textual descriptions, directly in your Markdown.



[Learn More](#)

Draggable Elements

Double-click on the draggable elements to edit their positions.

DIRECTIVE USAGE

```

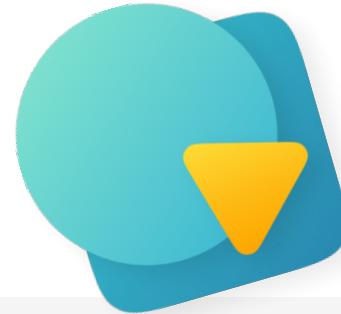
```

COMPONENT USAGE

```
<v-drag text-3xl>
  <carbon:arrow-up />
  Use the `v-drag` component to have a draggable container!
</v-drag>
```

DRAGGABLE ARROW

```
<v-drag-arrow two-way />
```



Double-click me!

Multiple Entries

You can split your slides.md into multiple files and organize them as you want using the `src` attribute.

slides.md

```
# Page 1

Page 2 from main entry.

---

## src: ./subpage.md
```

subpage.md

```
# Page 2

Page 2 from another file.
```

[Learn more](#)

Monaco Editor

Slidev provides built-in Monaco Editor support.

Add `{monaco}` to the code block to turn it into an editor:

```
import { ref } from 'vue'  
import { emptyArray } from './external'  
  
const arr = ref(emptyArray(10))
```

Use `{monaco-run}` to create an editor that can execute the code directly in the slide:

```
import { version } from 'vue'  
import { emptyArray, sayHello } from './external'  
  
sayHello()  
console.log(`vue ${version}`)  
console.log(emptyArray<number>(10).reduce(fib => [...fib, fib.at(-1)! + fib.at(-2)!], [1, 1]))
```

vue 3.4.27
[1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144]

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