Abstraction and Concept Invention: Towards Neuro-Symbolic Conceptual Blending

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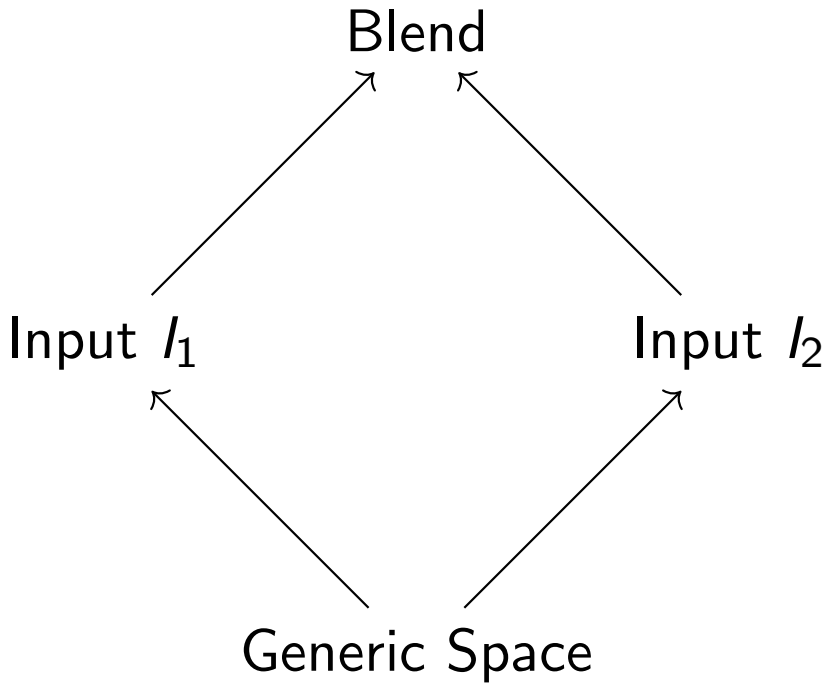
AUTONOME PROVINZ BOZEN SÜDTIROL

PROVINCIA AUTONOMA DI BOLZANO ALTO ADIGE

unibz

Conceptual Blending

- creative combination of input concepts
- based on conceptual information in form of a generic space



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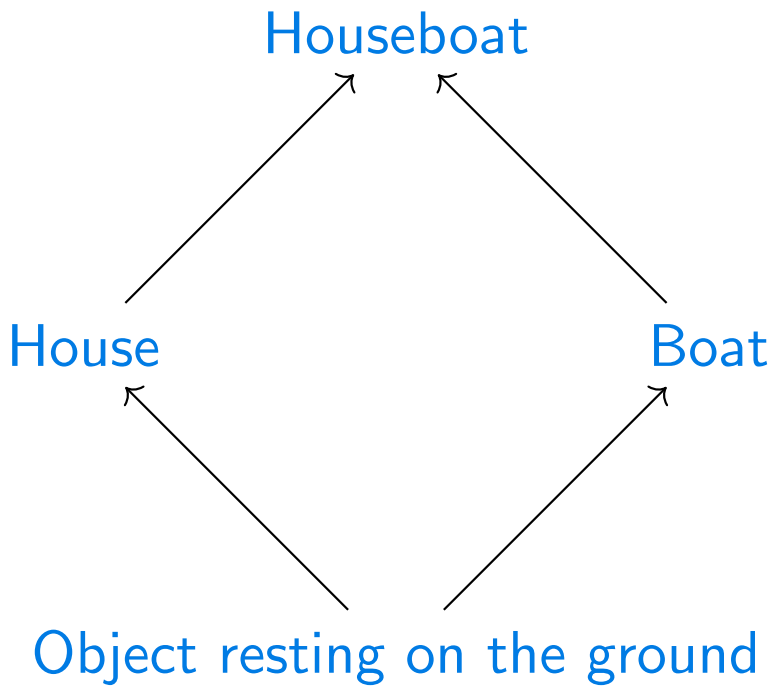
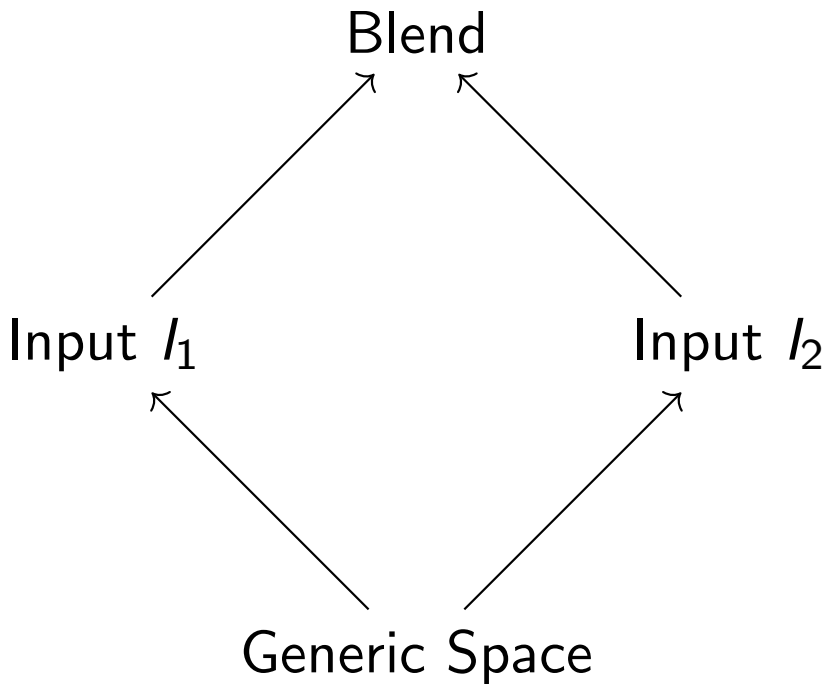


Abstraction in Conceptual Blending

- the generic space is an abstraction
- the abstraction determines the focus of the blend



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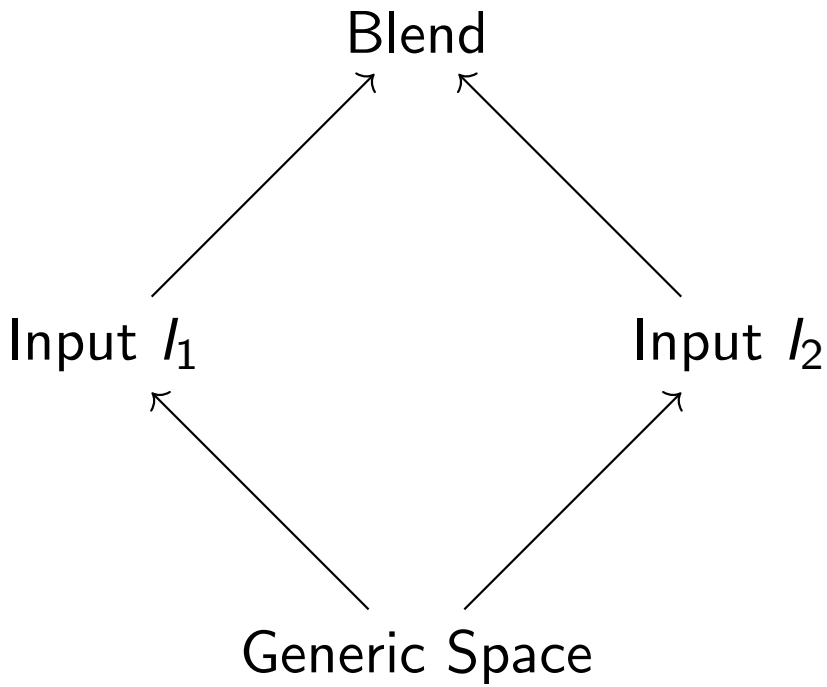


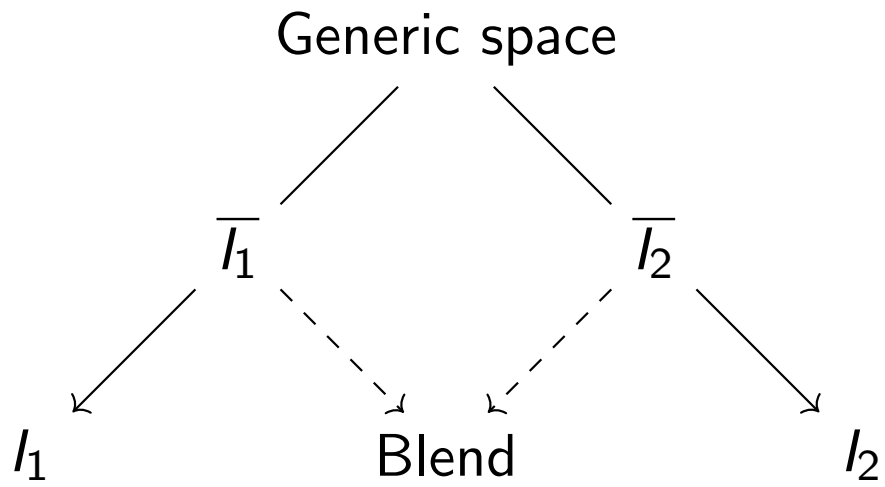
Question

How does a framework for conceptual blending look like?

A Symbolic Approach to Blending – Amalgamation

Amalgamation

- generalizing the input until a common generic space is reached
- combining two intermediate concepts to get a blend

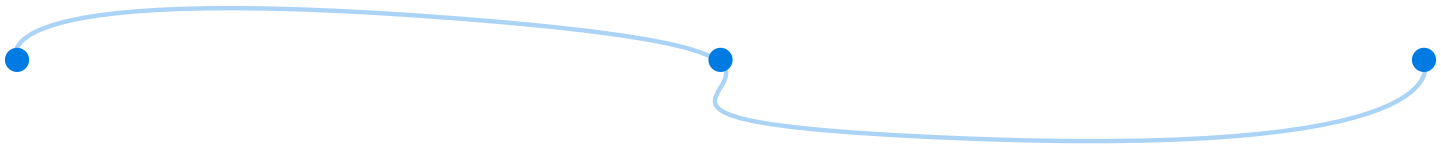


Challenge

1. *determination of the generic space*
2. *rating the blend quality*

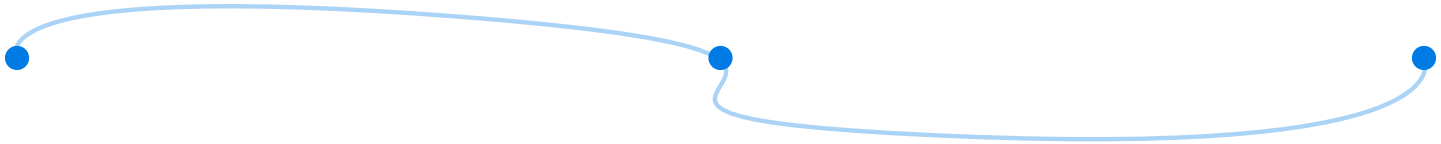
A Subsymbolic Approach to Blending – Visual Blending

Considering Latent Spaces – Visual Blending



(generated with the implementation of He et al., 2024)

Considering Latent Spaces – Visual Blending

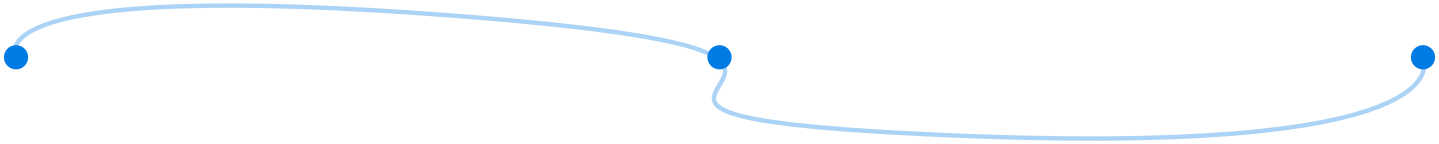


(generated with the implementation of He et al., 2024)

Advantage

- *saliency information*
- *running the blend*

Considering Latent Spaces – Visual Blending



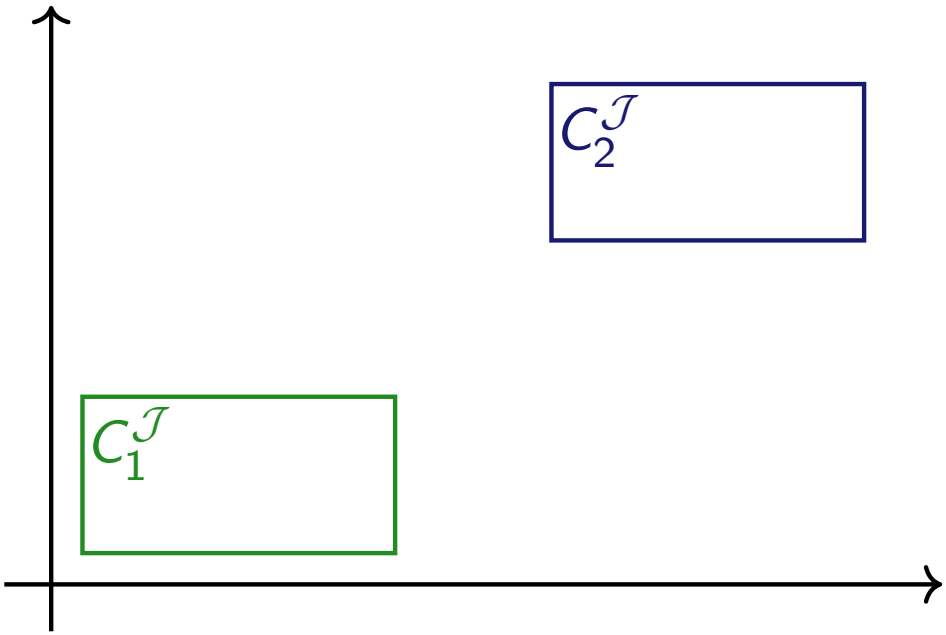
(generated with the implementation of He et al., 2024)

Challenge

1. *missing conceptual information*
2. *blend is not necessarily represented*

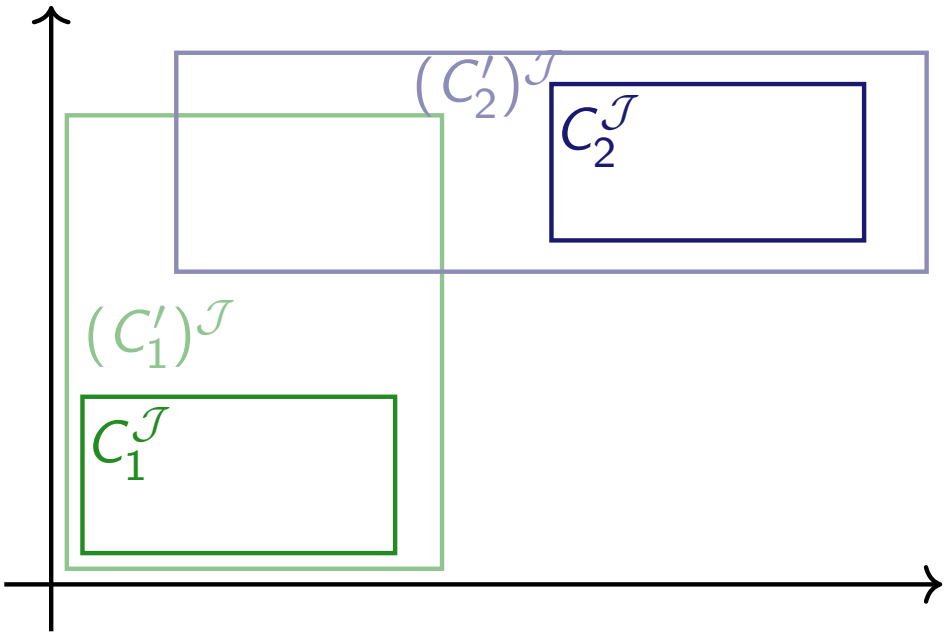
A **Neuro-Symbolic** Approach to Blending

Knowledge Base Embeddings



- modeling an ontology geometrically
- concepts as boxes
- logical operations as geometric operations

Knowledge Base Embeddings



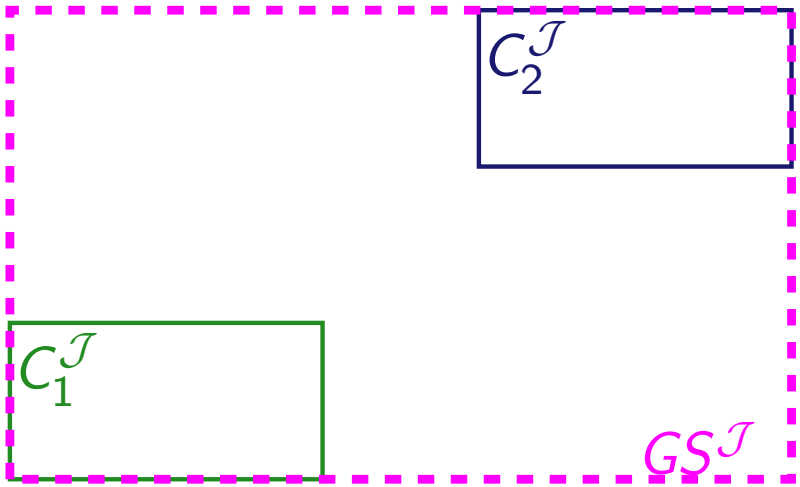
- modeling an ontology geometrically
- concepts as boxes
- logical operations as geometric operations

Pathomalgametry — Blending Path-finding, Amalgamation and Geometric Embeddings

Pathomalgametry

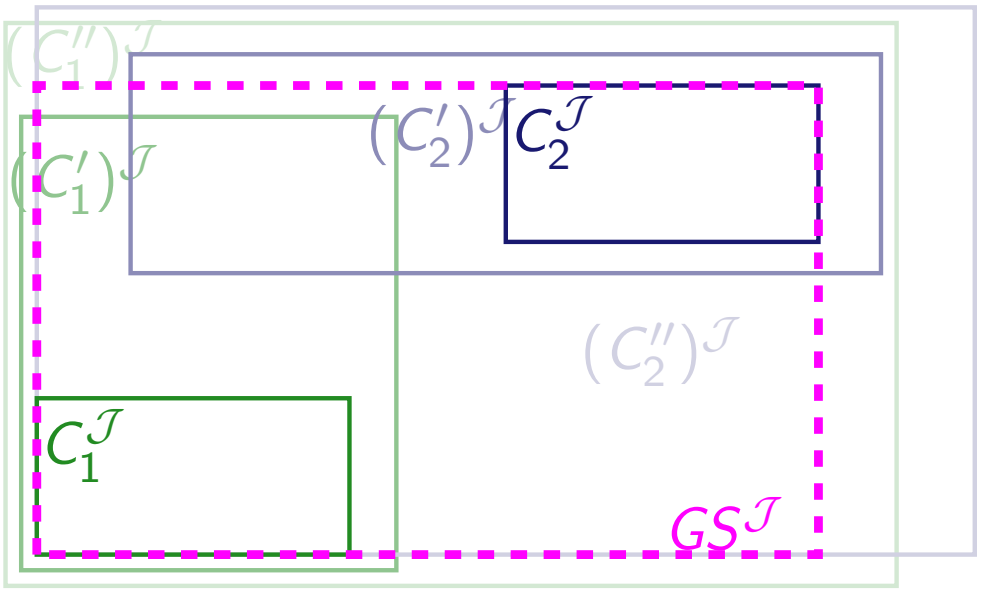
- input concepts C_1 and C_2

Pathomalgametry



- input concepts C_1 and C_2
- generic space GS represented geometrically

Pathomalgametry



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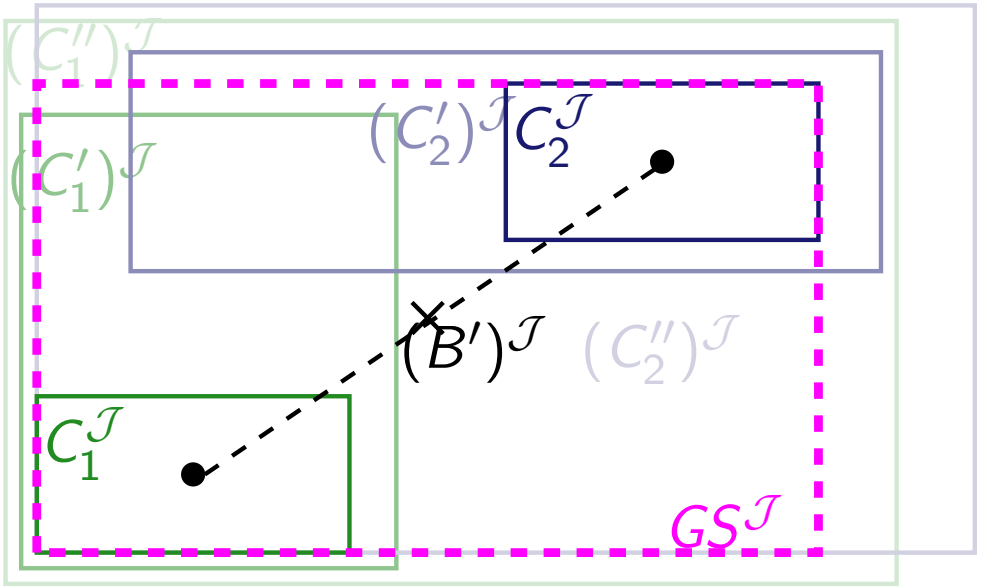
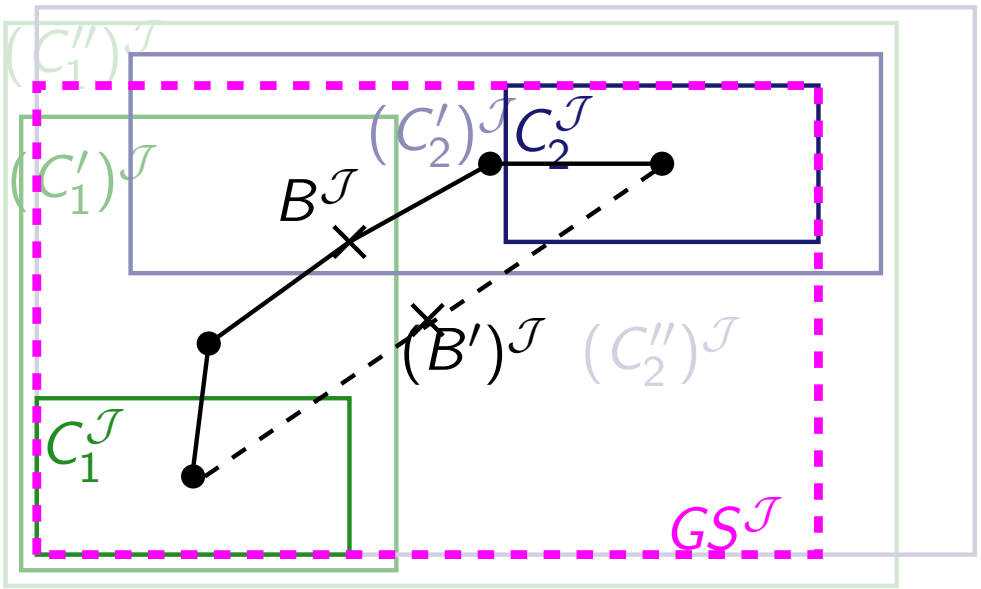
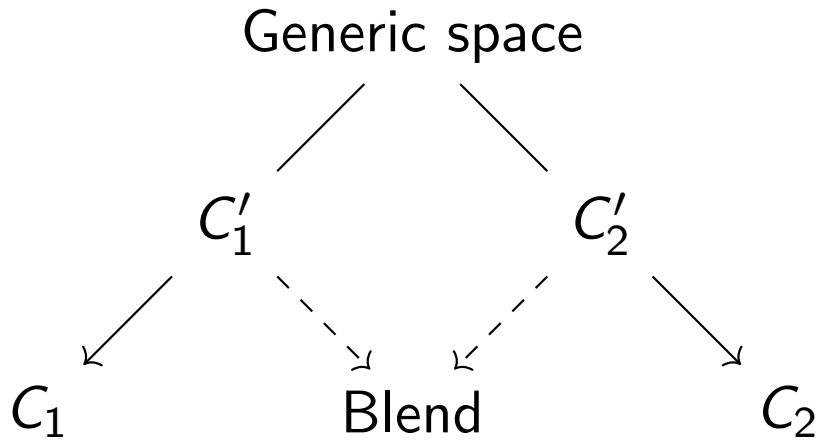
Pathomalgametry



- input concepts C_1 and C_2
- generic space GS represented geometrically
- examples for blends B and B'

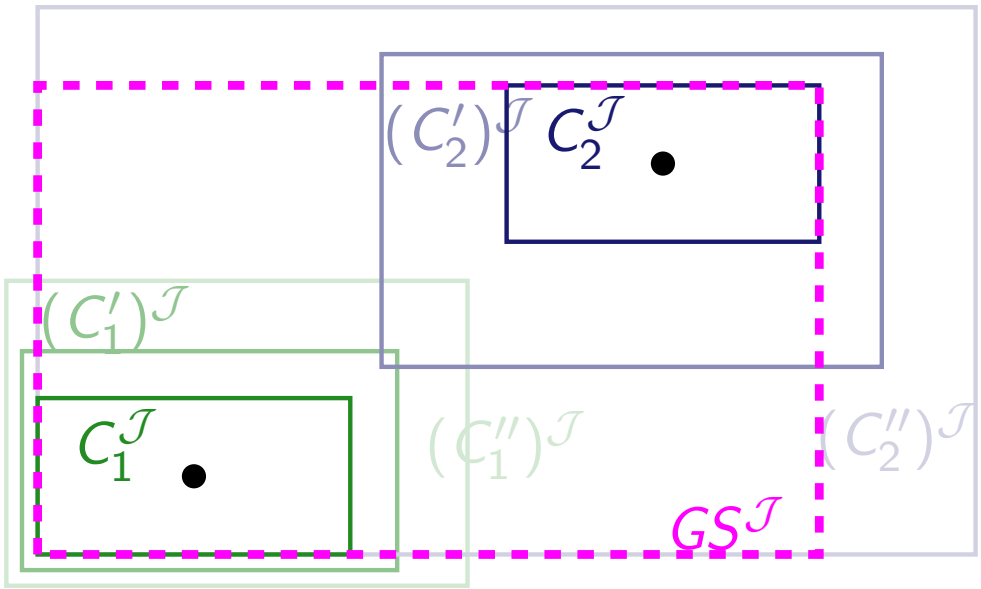
Pathomalgametry





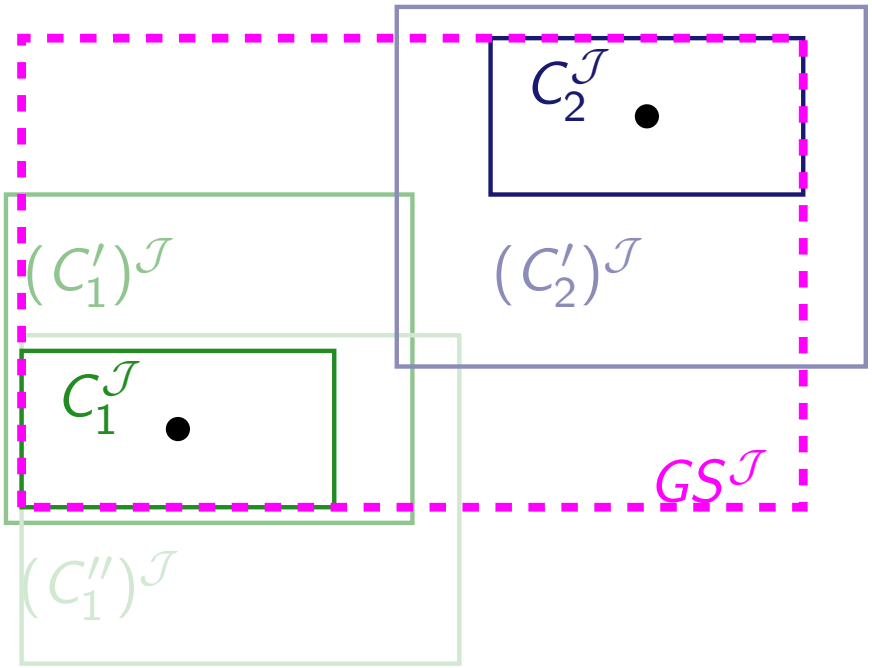
- path-finding due to quality measures
- determining optimality principles geometrically

Examples for Quality Measures I



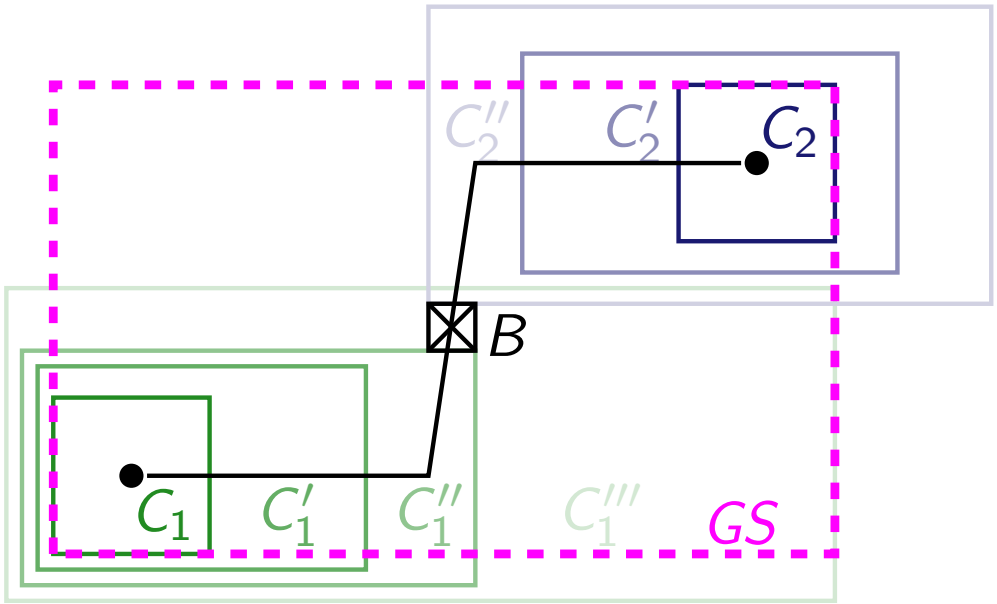
$\rightarrow$ prefer smaller generalizations over larger ones

Examples for Quality Measures II



$\rightarrow$ the generalization should conform to the generic space

Special Types of Blends



- the blend does not necessarily need to be represented
- approximation possible

Conclusion & Future Work

- neuro-symbolic conceptual blending
- incorporating a background knowledge ontology
- combing path-search, amalgamation and geometry

Future Work

- extensive experimental evaluation
- coping with imprecise embeddings
- testing of different quality measures and path-finding strategies

Bibliography I

Confalonieri, Roberto, Manfred Eppe, Marco Schorlemmer, Oliver Kutz, Rafael Peñaloza, and Enric Plaza (Aug. 2018). "Upward Refinement Operators for Conceptual Blending in the Description Logic $\mathcal{EL}^{++}$". In: *Annals of Mathematics and Artificial Intelligence* 82.1–3, pp. 69–99. ISSN: 1573-7470. DOI: 10.1007/s10472-016-9524-8.

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