



# Bootstrapping Template-Based Encodings of Ontologies

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## Motivation

Patterns for Ontologies  
Opacity of Patterns  
Identifying Patterns

## Regularity Discovery

Syntactic Similarity  
Syntactic Regularity  
Relations between  
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## Bootstrapping Templates

Axiom Templates  
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Generalisation to Sets

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Design Patterns

ODP Reuse



Pattern-Based Ontology

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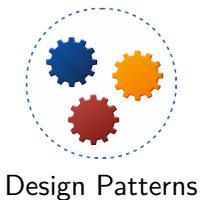
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Documented



Reuse



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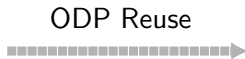
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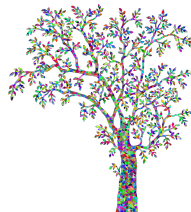
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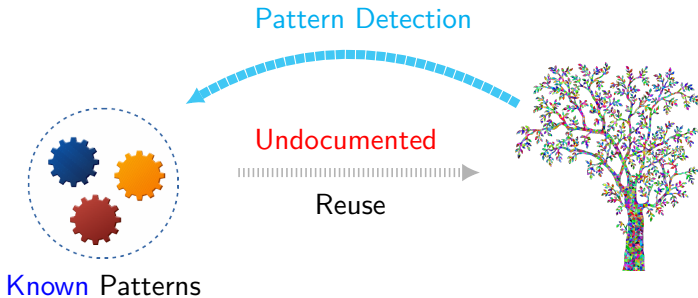
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Unknown Patterns



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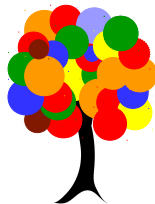
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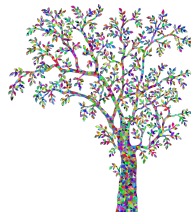


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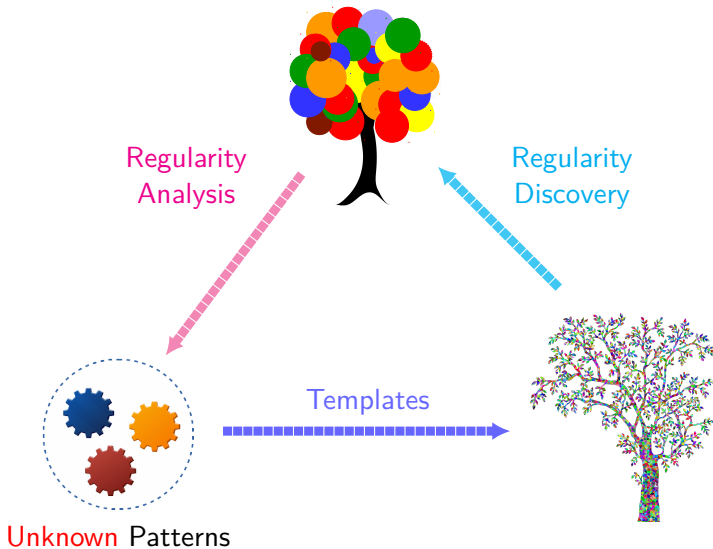
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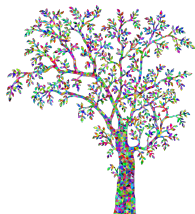
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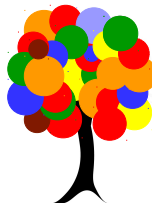
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# Regularity Discovery

# Syntactic Similarity



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UiO

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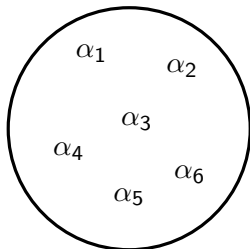
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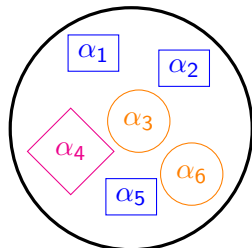
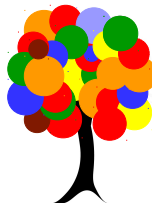
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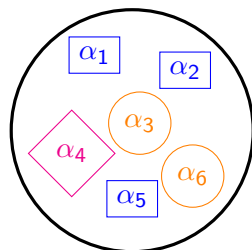
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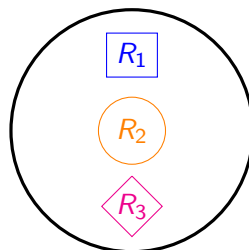
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$\alpha \mapsto R$



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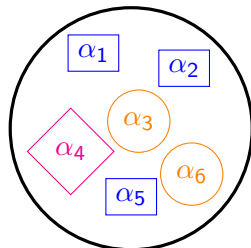
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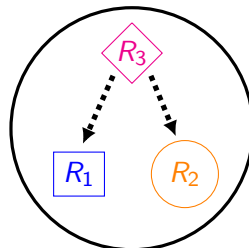
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$\alpha \mapsto R$



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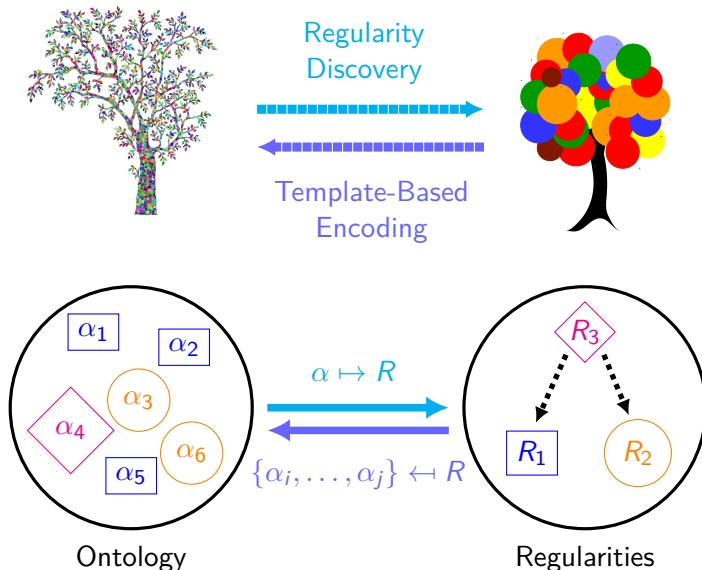
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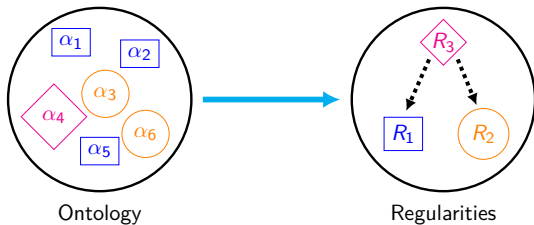
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# Bootstrapping Templates

# Basic Idea



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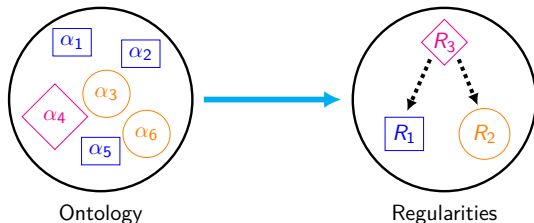
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# Basic Idea



$$\mathcal{O} = \left\{ \begin{array}{l} \alpha_1 = A_1 \sqsubseteq \exists R_1.B_1, \\ \alpha_2 = A_2 \sqsubseteq \exists R_2.B_2, \\ \alpha_3 = A_3 \sqsubseteq B_3 \sqcap B'_3, \\ \alpha_4 = A_4 \sqsubseteq \exists R_4.B_4, \\ \alpha_5 = A_5 \sqsubseteq B_5, \\ \alpha_6 = A_6 \sqsubseteq B_6 \sqcap B'_6 \end{array} \right\}$$

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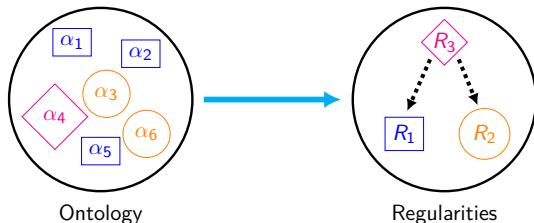
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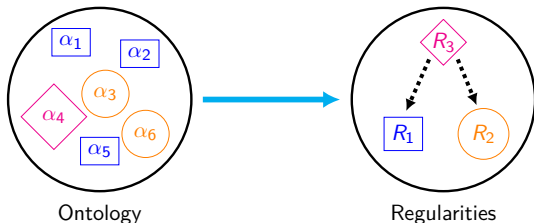
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# Basic Idea



$$\mathcal{O} = \left\{ \begin{array}{l} \alpha_1 = * \sqsubseteq \exists * .* , \\ \alpha_2 = * \sqsubseteq \exists * .* , \\ \alpha_3 = * \sqsubseteq * \sqcap * , \\ \alpha_4 = * \sqsubseteq \exists * .* , \\ \alpha_5 = * \sqsubseteq * , \\ \alpha_6 = * \sqsubseteq * \sqcap * \end{array} \right\}$$



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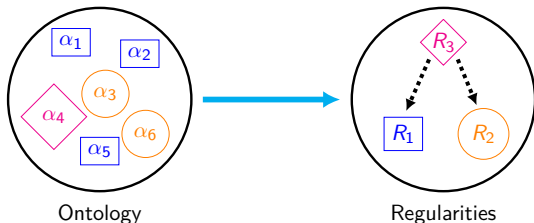
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# Basic Idea



$$\mathcal{O} = \left\{ \begin{array}{l} \alpha_1 = * \sqsubseteq \exists * .* , \\ \alpha_2 = * \sqsubseteq \exists * .* , \\ \alpha_3 = * \sqsubseteq * \sqcap * , \\ \alpha_4 = * \sqsubseteq \exists * .* , \\ \alpha_5 = * \sqsubseteq * , \\ \alpha_6 = * \sqsubseteq * \sqcap * \end{array} \right\}$$

$$R_1 : * \sqsubseteq \exists * .*$$

$$R_2 : * \sqsubseteq * \sqcap *$$

$$R_3 : * \sqsubseteq *$$

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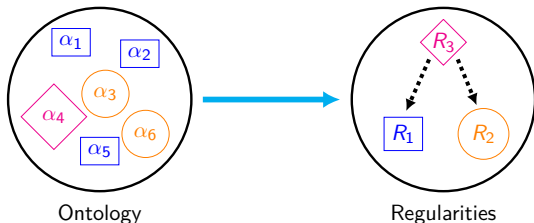
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$$\mathcal{O} = \left\{ \begin{array}{l} \alpha_1 = * \sqsubseteq \exists * .* , \\ \alpha_2 = * \sqsubseteq \exists * .* , \\ \alpha_3 = * \sqsubseteq * \sqcap * , \\ \alpha_4 = * \sqsubseteq \exists * .* , \\ \alpha_5 = * \sqsubseteq * , \\ \alpha_6 = * \sqsubseteq * \sqcap * \} \end{array} \right.$$

$$R_1 : * \sqsubseteq \exists * .*$$

$$R_2 : * \sqsubseteq * \sqcap *$$

$$R_3 : * \sqsubseteq *$$

$$T_1(x_1, x_2, x_3) :: \{x_1 \sqsubseteq \exists x_2.x_3\}$$



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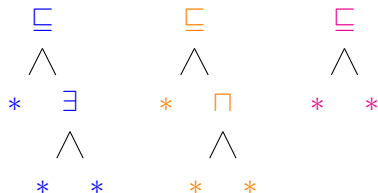
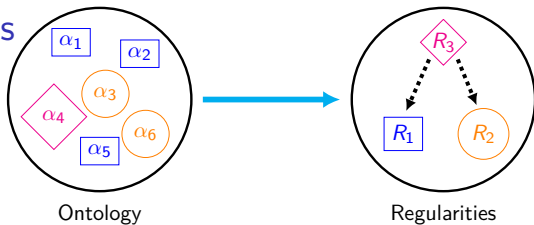
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# Substructures



$$R_1: * \sqsubseteq \exists * .*$$

$$R_2: * \sqsubseteq * \sqcap *$$

$$R_3: * \sqsubseteq *$$



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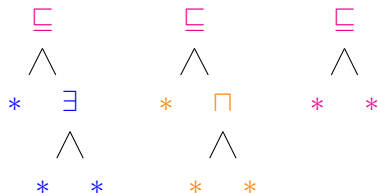
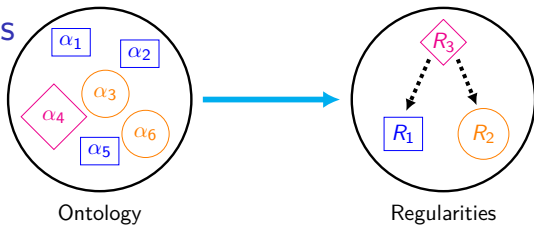
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# Substructures



$$R_1: * \square \exists * .*$$

$$R_2: * \square * \forall *$$

$$R_3: * \square *$$



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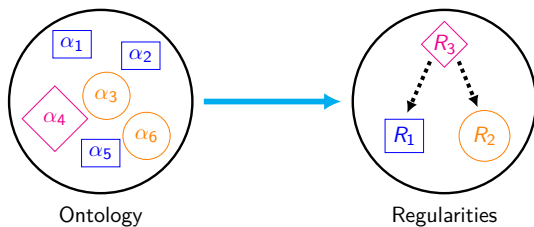
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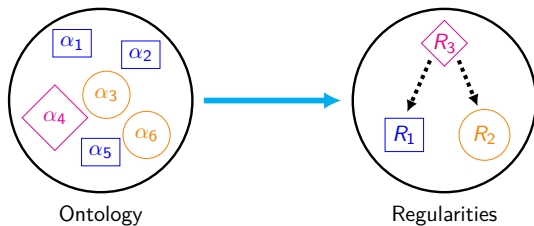
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$R_1$

$R_3$

$R_4$



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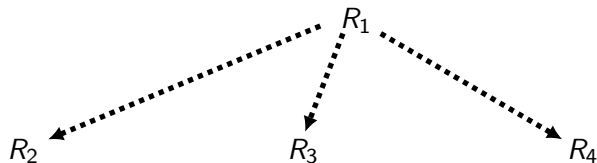
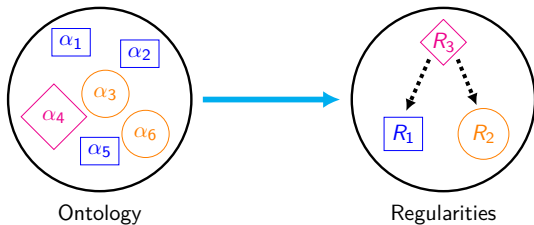
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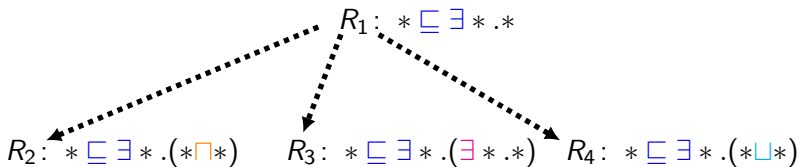
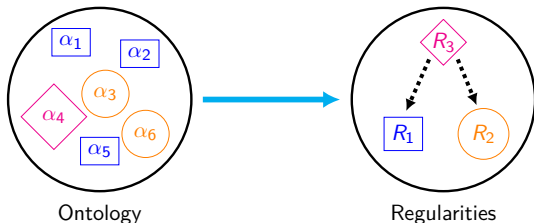
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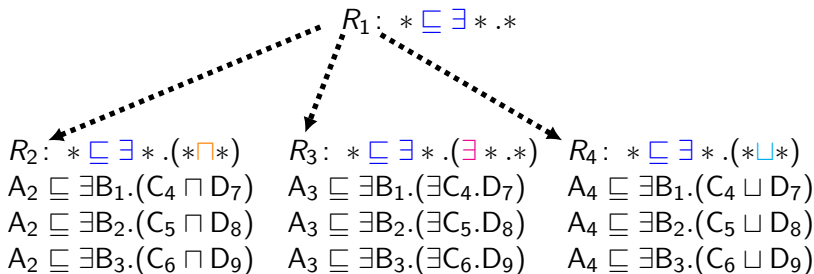
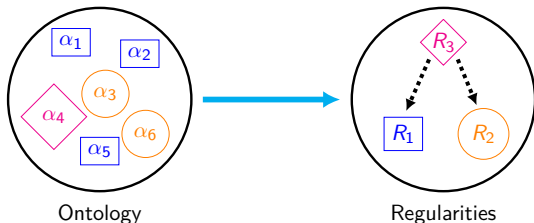
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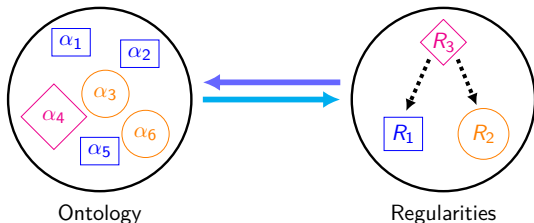
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$$T_1(x_1, x_2, x_3) :: \{x_1 \sqsubseteq \exists x_2 . x_3\}$$

$$R_1: * \sqsubseteq \exists * . *$$

$$R_2: * \sqsubseteq \exists * . (* \sqcap *)$$

$$A_2 \sqsubseteq \exists B_1 . (C_4 \sqcap D_7)$$

$$A_2 \sqsubseteq \exists B_2 . (C_5 \sqcap D_8)$$

$$A_2 \sqsubseteq \exists B_3 . (C_6 \sqcap D_9)$$

$$R_3: * \sqsubseteq \exists * . (\exists * . *)$$

$$A_3 \sqsubseteq \exists B_1 . (\exists C_4 . D_7)$$

$$A_3 \sqsubseteq \exists B_2 . (\exists C_5 . D_8)$$

$$A_3 \sqsubseteq \exists B_3 . (\exists C_6 . D_9)$$

$$R_4: * \sqsubseteq \exists * . (* \sqcup *)$$

$$A_4 \sqsubseteq \exists B_1 . (C_4 \sqcup D_7)$$

$$A_4 \sqsubseteq \exists B_2 . (C_5 \sqcup D_8)$$

$$A_4 \sqsubseteq \exists B_3 . (C_6 \sqcup D_9)$$



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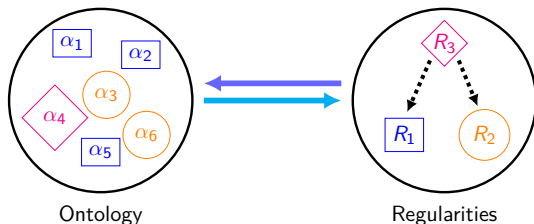
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$$T_1(x_1, x_2, x_3) :: \{x_1 \sqsubseteq \exists x_2.x_3\}$$

$$R_1: * \sqsubseteq \exists *.*$$

$$R_2: * \sqsubseteq \exists *.* (* \sqcap *)$$

$$A_2 \sqsubseteq \exists B_1.(C_4 \sqcap D_7)$$

$$A_2 \sqsubseteq \exists B_2.(C_5 \sqcap D_8)$$

$$A_2 \sqsubseteq \exists B_3.(C_6 \sqcap D_9)$$

$$T_1(A_2, B_1, C_4 \sqcap D_7)$$

...

$$R_3: * \sqsubseteq \exists *.* (\exists *.*)$$

$$A_3 \sqsubseteq \exists B_1.(\exists C_4.D_7)$$

$$A_3 \sqsubseteq \exists B_2.(\exists C_5.D_8)$$

$$A_3 \sqsubseteq \exists B_3.(\exists C_6.D_9)$$

$$T_1(A_3, B_1, \exists C_4.D_7)$$

...

$$R_4: * \sqsubseteq \exists *.* (* \sqcup *)$$

$$A_4 \sqsubseteq \exists B_1.(C_4 \sqcup D_7)$$

$$A_4 \sqsubseteq \exists B_2.(C_5 \sqcup D_8)$$

$$A_4 \sqsubseteq \exists B_3.(C_6 \sqcup D_9)$$

$$T_1(A_4, B_1, C_4 \sqcup D_7)$$

...

## Motivation

Patterns for Ontologies

Opacity of Patterns

Identifying Patterns

## Regularity Discovery

Syntactic Similarity

Syntactic Regularity

Relations between Regularities

Regularities

## Bootstrapping Templates

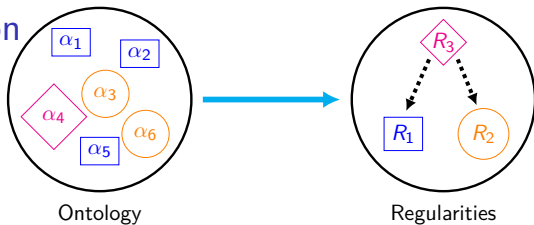
Axiom Templates

Choosing Templates

Generalisation to Sets

## Conclusion

# Generalisation



## Bootstrapping Encodings

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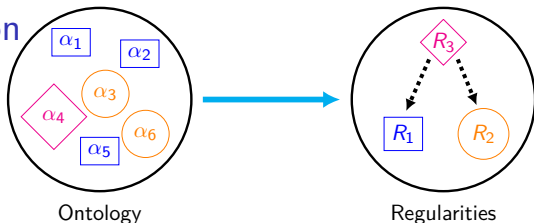
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# Generalisation



Reindeer  $\sqsubseteq \exists \text{hasSize.Normal}$   
Reindeer  $\sqsubseteq \exists \text{hasColour.Red}$   
Reindeer  $\sqsubseteq (= 4)\text{hasLimb.Leg}$

Moose  $\sqsubseteq \exists \text{hasSize.Large}$   
Moose  $\sqsubseteq \exists \text{hasColour.Brown}$   
Moose  $\sqsubseteq (= 4)\text{hasLimb.Leg}$



## Motivation

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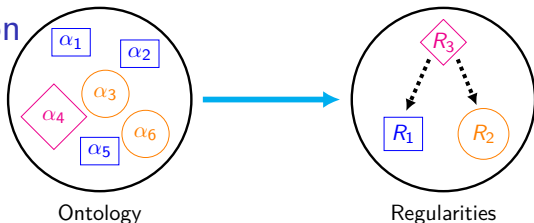
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# Generalisation



Reindeer  $\sqsubseteq \exists$ hasSize.Normal  
Reindeer  $\sqsubseteq \exists$ hasColour.Red  
Reindeer  $\sqsubseteq (=4)$ hasLimb.Leg

Moose  $\sqsubseteq \exists$ hasSize.Large  
Moose  $\sqsubseteq \exists$ hasColour.Brown  
Moose  $\sqsubseteq (=4)$ hasLimb.Leg

\*  $\sqsubseteq \exists$  \* .\*

\*  $\sqsubseteq \exists$  \* .\*

\*  $\sqsubseteq (=*)$  \* .\*



## Motivation

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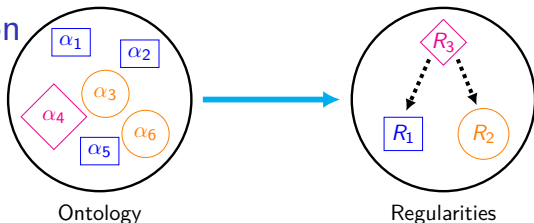
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# Generalisation



Reindeer  $\sqsubseteq \exists$ hasSize.Normal

Reindeer  $\sqsubseteq \exists$ hasColour.Red

\*  $\sqsubseteq \exists$  \* .\*

\*  $\sqsubseteq \exists$  \* .\*

Moose  $\sqsubseteq \exists$ hasSize.Large

Moose  $\sqsubseteq \exists$ hasColour.Brown

Moose  $\sqsubseteq (=4)$ hasLimb.Leg

\*  $\sqsubseteq \exists$  \* .\*

\*  $\sqsubseteq \exists$  \* .\*

\*  $\sqsubseteq (=*)$  \* .\*



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- We can identify **structural regularities**
- We can identify **substructure relationships** between regularities
- We can **encode variability** with templates