

Онтологический подход к оценке GraphRAG в PLM-домене. Приложения.

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Приложение 1

Извлечённая из схемы данных AP214E3_2010.exp онтология структуры данных s1-c5-214_Schema_DL.owl (TBox). Более 13000 аксиом (фрагмент):

Prefix(:=<http://www.nist.gov/On toSTEP/automotive_design#>)

Prefix(owl:=<http://www.w3.org/2002/07/owl#>)

Prefix(rdf:=<http://www.w3.org/1999/02/22-rdf-syntax-ns#>)

Prefix(xml:=<http://www.w3.org/XML/1998/namespace>)

Prefix(xsd:=<http://www.w3.org/2001/XMLSchema#>)

Prefix(rdfs:=<http://www.w3.org/2000/01/rdf-schema#>)

Ontology(<http://www.nist.gov/On toSTEP/automotive_design>

Declaration(Class(:founded_item))

Declaration(Class(:founded_item_select))

Declaration(Class(:set_of_founded_item_select))

Declaration(Class(:curve_style))

Declaration(Class(:label))

Declaration(Class(:curve_font_or_scaled_curve_font_select))

Declaration(Class(:size_select))

Declaration(Class(:colour))

Declaration(Class(:pair_value))

Declaration(Class(:kinematic_pair))

Declaration(Class(:point_on_surface_pair_value))

Declaration(Class(:point_on_surface))

Declaration(Class(:spatial_rotation))

Declaration(Class(:plane_angle_measure))

Declaration(Class(:array_of_plane_angle_measure))

Declaration(Class(:emptyarray_of_plane_angle_measure))

Declaration(Class(:generic_expression))

Declaration(Class(:literal_number))

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Declaration(Class(:number))
Declaration(Class(:real_literal))

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# Object Properties

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# Object Property: :set_of_founded_item_select_has_content
(:set_of_founded_item_select_has_content)

ObjectPropertyDomain(:set_of_founded_item_select_has_content :set_of_founded_item_select)
ObjectPropertyRange(:set_of_founded_item_select_has_content :founded_item_select)

# Object Property: :curve_style_has_name (:curve_style_has_name)

AnnotationAssertion(:OPType :curve_style_has_name "label"^^xsd:string)
AnnotationAssertion(:ParameterIndex :curve_style_has_name "0"^^xsd:integer)
ObjectPropertyDomain(:curve_style_has_name :curve_style)
ObjectPropertyRange(:curve_style_has_name :label)

# Object Property: :curve_style_has_curve_font (:curve_style_has_curve_font)

AnnotationAssertion(:OPType :curve_style_has_curve_font
"curve_font_or_scaled_curve_font_select"^^xsd:string)
AnnotationAssertion(:ParameterIndex :curve_style_has_curve_font "1"^^xsd:integer)
ObjectPropertyDomain(:curve_style_has_curve_font :curve_style)
ObjectPropertyRange(:curve_style_has_curve_font :curve_font_or_scaled_curve_font_select)

# Object Property: :curve_style_has_curve_width (:curve_style_has_curve_width)

AnnotationAssertion(:OPType :curve_style_has_curve_width "size_select"^^xsd:string)
AnnotationAssertion(:ParameterIndex :curve_style_has_curve_width "2"^^xsd:integer)
ObjectPropertyDomain(:curve_style_has_curve_width :curve_style)

...

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Data Properties

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Data Property: :to_binary (:to_binary)

DataPropertyDomain(:to_binary :binary)

DataPropertyRange(:to_binary xsd:hexBinary)

Data Property: :to_boolean (:to_boolean)

DataPropertyDomain(:to_boolean :boolean)

DataPropertyRange(:to_boolean xsd:boolean)

Data Property: :to_decimal (:to_decimal)

DataPropertyDomain(:to_decimal :real)

DataPropertyDomain(:to_decimal :number)

DataPropertyRange(:to_decimal xsd:decimal)

Data Property: :to_integer (:to_integer)

DataPropertyDomain(:to_integer :integer)

DataPropertyRange(:to_integer xsd:integer)

Data Property: :to_string (:to_string)

DataPropertyDomain(:to_string :string)

DataPropertyRange(:to_string xsd:string)

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Classes

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Class: :founded_item (:founded_item)

AnnotationAssertion(:ExpConstruct :founded_item "entity"^^xsd:string)

SubClassOf(Annotation(:SupertypeIndex "0"^^xsd:integer) :founded_item :founded_item_select)

Class: :founded_item_select (:founded_item_select)

AnnotationAssertion(:ExpConstruct :founded_item_select "selecttype"^^xsd:string)

Class: :set_of_founded_item_select (:set_of_founded_item_select)

AnnotationAssertion(:ExpConstruct :set_of_founded_item_select "set"^^xsd:string)

SubClassOf(:set_of_founded_item_select

ObjectAllValuesFrom(:set_of_founded_item_select_has_content :founded_item_select))

Class: :curve_style (:curve_style)

AnnotationAssertion(:ExpConstruct :curve_style "entity"^^xsd:string)

SubClassOf(Annotation(:SupertypeIndex "0"^^xsd:integer) :curve_style :founded_item)

SubClassOf(Annotation(:SupertypeIndex "1"^^xsd:integer) :curve_style :presentation_style_select)

SubClassOf(Annotation(:SupertypeIndex "2"^^xsd:integer) :curve_style :curve_or_render)

SubClassOf(:curve_style ObjectAllValuesFrom(:curve_style_has_name :label))

SubClassOf(:curve_style ObjectExactCardinality(1 :curve_style_has_name))

SubClassOf(:curve_style

ObjectAllValuesFrom(:curve_style_has_curve_font :curve_font_or_scaled_curve_font_select))

SubClassOf(:curve_style ObjectExactCardinality(1 :curve_style_has_curve_font))

SubClassOf(:curve_style ObjectAllValuesFrom(:curve_style_has_curve_width :size_select))

SubClassOf(:curve_style ObjectExactCardinality(1 :curve_style_has_curve_width))

SubClassOf(:curve_style ObjectAllValuesFrom(:curve_style_has_curve_colour :colour))

SubClassOf(:curve_style ObjectExactCardinality(1 :curve_style_has_curve_colour))

...

Приложение 2

Извлечённая из сборки s1-c5-214.stp онтология экземпляра сборки s1-c5-214_Instances_DL.owl (ABox) Около 1000 экземпляров (Фрагмент):

Prefix(:=<http://www.nist.gov/OntoSTEP/instances#>)

Prefix(step:=<http://www.nist.gov/OntoSTEP/automotive_design#>)

Prefix(owl:=<http://www.w3.org/2002/07/owl#>)

Prefix(rdf:=<http://www.w3.org/1999/02/22-rdf-syntax-ns#>)

Prefix(xml:=<http://www.w3.org/XML/1998/namespace>)

Prefix(xsd:=<http://www.w3.org/2001/XMLSchema#>)

Prefix(rdfs:=<http://www.w3.org/2000/01/rdf-schema#>)

Ontology(<http://www.nist.gov/OntoSTEP/instances>

Import(<http://www.nist.gov/OntoSTEP/automotive_design>)

Declaration(NamedIndividual(:i5))

Declaration(NamedIndividual(:i5_id))

Declaration(NamedIndividual(:i5_name))

Declaration(NamedIndividual(:i5_description))

Declaration(NamedIndividual(:i5_frame_of_reference))

Declaration(NamedIndividual(:i2))

Declaration(NamedIndividual(:i28))

Declaration(NamedIndividual(:i28_id))

Declaration(NamedIndividual(:i28_name))

Declaration(NamedIndividual(:i28_description))

Declaration(NamedIndividual(:i28_frame_of_reference))

Declaration(NamedIndividual(:i68))

Declaration(NamedIndividual(:i68_id))

Declaration(NamedIndividual(:i68_name))

Declaration(NamedIndividual(:i68_description))

Declaration(NamedIndividual(:i68_frame_of_reference))

Declaration(NamedIndividual(:i108))

Declaration(NamedIndividual(:i108_id))

...

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Named Individuals

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Individual: :i5 (:i5)

ClassAssertion(step:product :i5)

ObjectPropertyAssertion(step:product_has_id :i5 :i5_id)

ObjectPropertyAssertion(step:product_has_name :i5 :i5_name)

ObjectPropertyAssertion(step:product_has_description :i5 :i5_description)

ObjectPropertyAssertion(step:product_has_frame_of_reference :i5 :i5_frame_of_reference)

Individual: :i5_id (:i5_id)

ClassAssertion(step:identifier :i5_id)

DataPropertyAssertion(step:to_string :i5_id "*MASTER"^^xsd:string)

Individual: :i5_name (:i5_name)

ClassAssertion(step:label :i5_name)

DataPropertyAssertion(step:to_string :i5_name "*MASTER"^^xsd:string)

Individual: :i5_description (:i5_description)

ClassAssertion(step:text :i5_description)

DataPropertyAssertion(step:to_string :i5_description " "^^xsd:string)

Individual: :i5_frame_of_reference (:i5_frame_of_reference)

ClassAssertion(step:set_of_product_context :i5_frame_of_reference)

ObjectPropertyAssertion(step:set_of_product_context_has_content :i5_frame_of_reference :i2)

...

Приложение 3

Файл s1-c5-214.stp_Schema_DL.txt в формате Attempto Controlled English (Фрагмент):

Every ahead_or_behind is something that is ahead or that is behind or that is exact.

Everything that is ahead or that is behind or that is exact is an ahead_or_behind.

Every angle_relator is something that is equal or that is large or that is small.

Everything that is equal or that is large or that is small is an angle_relator.

Every approximation_method is something that is chordal_deviation or that is chordal_length.

Everything that is chordal_deviation or that is chordal_length is an approximation_method.

Every b_spline_curve is something that is a b_spline_curve_with_knots or that is a bezier_curve or that is a quasi_uniform_curve or that is a rational_b_spline_curve or that is a uniform_curve.

Everything that is a b_spline_curve_with_knots or that is a bezier_curve or that is a quasi_uniform_curve or that is a rational_b_spline_curve or that is a uniform_curve is a b_spline_curve.

...

If X list_of_style_context_select_is_followed_by something that list_of_style_context_select_is_followed_by Y then X list_of_style_context_select_is_followed_by Y.

If X list_of_surface_patch_is_followed_by something that list_of_surface_patch_is_followed_by Y then X list_of_surface_patch_is_followed_by Y.

Everything that action_assignment_has_assigned_action something is an action_assignment.

Everything that action_directive_has_analysis something is an action_directive.

Everything that action_directive_has_comment something is an action_directive.

Everything that action_directive_has_description something is an action_directive.

Everything that action_directive_has_name something is an action_directive.

Everything that action_directive_has_requests something is an action_directive.

Everything that action_resource_has_kind something is an action_resource.

Everything that action_resource_has_name something is an action_resource.

Everything that action_resource_has_usage something is an action_resource.

Everything that action_resource_requirement_has_description something is an action_resource_requirement.

Everything that action_resource_requirement_has_kind something is an action_resource_requirement.

Everything that action_resource_requirement_has_name something is an action_resource_requirement.

Everything that action_resource_requirement_has_operations something is an action_resource_requirement.

Everything that action_resource_type_has_name something is an action_resource_type.

Everything that action_status_has_assigned_action something is an action_status.

Everything that action_status_has_status something is an action_status.

...

Every logical is something that is FALSE or that is TRUE or that is UNKNOWN.

Everything that is FALSE or that is TRUE or that is UNKNOWN is a logical.

Every marker_type is something that is asterisk or that is dot or that is plus or that is ring or that is square or that is triangle or that is x.

Everything that is asterisk or that is dot or that is plus or that is ring or that is square or that is triangle or that is x is a marker_type.

Every named_unit is something that is an amount_of_substance_unit or that is an electric_current_unit or that is a length_unit or that is a luminous_intensity_unit or that is a mass_unit or that is a plane_angle_unit or that is a ratio_unit or that is a solid_angle_unit or that is a thermodynamic_temperature_unit or that is a time_unit or that is something that is a context_dependent_unit or that is a conversion_based_unit or that is a si_unit.

...

Приложение 4

Файл s1-c5-214.stp_Instances_DL.txt в формате Attempto Controlled English (Фрагмент):

i1 is an application_context.

i10 is a product_category.

i100 is a direction.

i100_direction_ratios_1 is a list_of_real.

i100_direction_ratios_1_value is a real.

i100_direction_ratios_2 is a list_of_real.

i100_direction_ratios_2_value is a real.

i100_direction_ratios_3 is a list_of_real.

i100_direction_ratios_3_value is a real.

i100_direction_ratios_last is an emptylist_of_real.

i100_name is a label.

i101 is a length_measure_with_unit.

i101_value_component is a length_measure.

i102 is a dimensional_exponents.

i102_amount_of_substance_exponent is a real.

i102_electric_current_exponent is a real.

i102_length_exponent is a real.

i102_luminous_intensity_exponent is a real.

i102_mass_exponent is a real.

i102_thermodynamic_temperature_exponent is a real.

i102_time_exponent is a real.

i103 is a conversion_based_unit.

i103 is a length_unit.

i103 is a named_unit.

i103_name is a label.

i104 is an uncertainty_measure_with_unit.

i104_description is a text.

i104_name is a label.

i104_value_component is a length_measure.

i105 is a geometric_representation_context.

i105 is a global_uncertainty_assigned_context.
i105 is a global_unit_assigned_context.
i105 is a representation_context.
i105_context_identifier is an identifier.
i105_context_type is a text.
i105_coordinate_space_dimension is a dimension_count.
i105_uncertainty is a set_of_uncertainty_measure_with_unit.
i105_units is a set_of_unit.
i106 is a shape_representation.
i106_items is a set_of_representation_item.
i106_name is a label.
i107 is a shape_definition_representation.
i108 is a product.
i108_description is a text.
i108_frame_of_reference is a set_of_product_context.
i108_id is an identifier.
i108_name is a label.
i109 is a product_definition_formation_with_specified_source.
i109_description is a text.
i109_id is an identifier.
i10_description is a text.
i10_name is a label.
i11 is a product_related_product_category.
i110 is a product_definition.
i110_description is a text.
i110_id is an identifier.
i111 is a product_definition_shape.
i111_description is a text.
i111_name is a label.
i112 is an external_source.
i112_source_id is an identifier.
i113 is a document_file.
i113_description is a text.
...

Приложение 5

Набор отобранных аксиом относительно объекта i101

i101 is a length_measure_with_unit.

i101_value_component is a length_measure.

i101 measure_with_unit_has_unit_component i17.

i101 measure_with_unit_has_value_component i101_value_component.

i103 conversion_based_unit_has_conversion_factor i101.

i103 is a conversion_based_unit.

i103 is a length_unit.

i103 is a named_unit.

i103_name is a label.

i103 conversion_based_unit_has_name i103_name.

i104 measure_with_unit_has_unit_component i103.

i105_units set_of_unit_has_content i103.

Everything that is conical_surface_has_radius by a conical_surface is a length_measure.

Everything that is cylindrical_pair_value_has_actual_translation by a cylindrical_pair_value is a length_measure.

Everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit.

Every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing.

Everything that measure_with_unit_has_unit_component something is a measure_with_unit.

Everything that is measure_with_unit_has_unit_component by something is a unit.

Everything that is measure_with_unit_has_value_component by a measure_with_unit is a measure_value.

Every measure_with_unit measure_with_unit_has_value_component exactly 1 thing.

Everything that measure_with_unit_has_value_component something is a measure_with_unit.

Everything that is measure_with_unit_has_value_component by something is a measure_value.

Everything that is conversion_based_unit_has_conversion_factor by a conversion_based_unit is a measure_with_unit.

Every conversion_based_unit conversion_based_unit_has_conversion_factor exactly 1 thing.

Everything that conversion_based_unit_has_conversion_factor something is a conversion_based_unit.

Everything that is conversion_based_unit_has_conversion_factor by something is a measure_with_unit.

Everything that is set_of_unit_has_content by a set_of_unit is a unit.

Everything that is set_of_unit_has_content by something is a unit.

Everything that is geometric_tolerance_has_magnitude by a geometric_tolerance is a measure_with_unit.

Everything that is geometric_tolerance_with_defined_unit_has_unit_size by a geometric_tolerance_with_defined_unit is a measure_with_unit.

Everything that is value_representation_item_has_value_component by a value_representation_item is a measure_value.

Everything that is value_representation_item_has_value_component by something is a measure_value.

Every named_unit is something that is an amount_of_substance_unit or that is an electric_current_unit or that is a length_unit or that is a luminous_intensity_unit or that is a mass_unit or that is a plane_angle_unit or that is a ratio_unit or that is a solid_angle_unit or that is a thermodynamic_temperature_unit or that is a time_unit or that is something that is a context_dependent_unit or that is a conversion_based_unit or that is a si_unit.

Everything that is an amount_of_substance_unit or that is an electric_current_unit or that is a length_unit or that is a luminous_intensity_unit or that is a mass_unit or that is a plane_angle_unit or that is a ratio_unit or that is a solid_angle_unit or that is a thermodynamic_temperature_unit or that is a time_unit or that is something that is a context_dependent_unit or that is a conversion_based_unit or that is a si_unit is a named_unit.

Everything that is conversion_based_unit_has_name by a conversion_based_unit is a label.

Every conversion_based_unit conversion_based_unit_has_name exactly 1 thing.

Everything that conversion_based_unit_has_name something is a conversion_based_unit.

Everything that is conversion_based_unit_has_name by something is a label.

Every set_of_unit set_of_unit_has_content at least 1 thing.

Everything that set_of_unit_has_content something is a set_of_unit.

Приложение 6

Промпт 1 - Answer with Attempto Controlled English. Show the axioms logically related to i101

Модель Anthropic Claude Sonnet 4.5:

Axioms Logically Related to i101

Based on the fact that i101 is a `length_measure_with_unit` and participates in several relations, the following axioms are logically related:

Axioms for `measure_with_unit_has_unit_component` relation

(i101 `measure_with_unit_has_unit_component` i17)

- Everything that is `measure_with_unit_has_unit_component` by a `measure_with_unit` is a unit.
- Every `measure_with_unit` `measure_with_unit_has_unit_component` exactly 1 thing.
- Everything that `measure_with_unit_has_unit_component` something is a `measure_with_unit`.
- Everything that is `measure_with_unit_has_unit_component` by something is a unit.

Axioms for `measure_with_unit_has_value_component` relation

(i101 `measure_with_unit_has_value_component` i101_value_component)

- Everything that is `measure_with_unit_has_value_component` by a `measure_with_unit` is a `measure_value`.
- Every `measure_with_unit` `measure_with_unit_has_value_component` exactly 1 thing.
- Everything that `measure_with_unit_has_value_component` something is a `measure_with_unit`.
- Everything that is `measure_with_unit_has_value_component` by something is a `measure_value`.

Axioms for `conversion_based_unit_has_conversion_factor` relation

(i103 `conversion_based_unit_has_conversion_factor` i101)

- Everything that is `conversion_based_unit_has_conversion_factor` by a `conversion_based_unit` is a `measure_with_unit`.
- Every `conversion_based_unit` `conversion_based_unit_has_conversion_factor` exactly 1 thing.
- Everything that `conversion_based_unit_has_conversion_factor` something is a `conversion_based_unit`.
- Everything that is `conversion_based_unit_has_conversion_factor` by something is a `measure_with_unit`.

Модель Qwen 3 Max:

i101 is a `measure_with_unit`.

i17 is a unit.

i101_value_component is a `measure_value`.

i101_value_component is a `length_measure` and a `measure_value`.

i101 has exactly 1 `unit_component`.

i101 has exactly 1 `value_component`.

i101 is a `conversion_factor` of i103.

i103 is a `conversion_based_unit` that has `conversion_factor` i101.

Every `conversion_based_unit` that has `conversion_factor` i101 is i103.

Every `measure_with_unit` that has `unit_component` i17 is i101.

Every `measure_with_unit` that has `value_component` i101_value_component is i101.

Модель GPT-5-mini:

i101 is a length_measure_with_unit.
i101_value_component is a length_measure.
i101 measure_with_unit_has_unit_component i17.
i101 measure_with_unit_has_value_component i101_value_component.
i103 conversion_based_unit_has_conversion_factor i101.

Everything that is conversion_based_unit_has_conversion_factor by a conversion_based_unit is a measure_with_unit.
Every conversion_based_unit conversion_based_unit_has_conversion_factor exactly 1 thing.
Everything that conversion_based_unit_has_conversion_factor something is a conversion_based_unit.
Everything that is conversion_based_unit_has_conversion_factor by something is a measure_with_unit.

Everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit.
Every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing.
Everything that measure_with_unit_has_unit_component something is a measure_with_unit.
Everything that is measure_with_unit_has_value_component by a measure_with_unit is a measure_value.
Every measure_with_unit measure_with_unit_has_value_component exactly 1 thing.
Everything that measure_with_unit_has_value_component something is a measure_with_unit.

Промпт 2 - Answer with Attempto Controlled English. Draw logical conclusions based on the axioms regarding i101

Модель Anthropic Claude Sonnet 4.5:

Logical Conclusions about i101

Based on the given axioms and facts, the following can be concluded about i101:

Direct Classifications

- **i101 is a measure_with_unit** (derived from the axiom "Everything that measure_with_unit_has_unit_component something is a measure_with_unit" and the fact that i101 measure_with_unit_has_unit_component i17)
- **i101 is a length_measure_with_unit** (given)

Relationships and Components

Unit Component

- **i17 is a unit** (derived from the axiom "Everything that is measure_with_unit_has_unit_component by something is a unit")
- **i101 measure_with_unit_has_unit_component exactly 1 thing, namely i17** (from the uniqueness constraint and the given fact)

Value Component

- **i101_value_component is a measure_value** (derived from the axiom "Everything that is measure_with_unit_has_value_component by something is a measure_value")
- **i101_value_component is a length_measure** (given)
- **i101 measure_with_unit_has_value_component exactly 1 thing, namely i101_value_component** (from the uniqueness constraint and the given fact)

Role as Conversion Factor

- **i101 serves as the conversion factor for i103** (i103 conversion_based_unit_has_conversion_factor i101)
- **i101 is used by a conversion_based_unit** (specifically by i103, which is a conversion_based_unit, a length_unit, and a named_unit)

Модель Qwen 3 Max:

i101 is a length_measure_with_unit.
i101_value_component is a length_measure.
i101 measure_with_unit_has_unit_component i17.
i101 measure_with_unit_has_value_component i101_value_component.
i103 conversion_based_unit_has_conversion_factor i101.

Everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit.

Every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing.
Everything that measure_with_unit_has_unit_component something is a measure_with_unit.

Everything that is measure_with_unit_has_unit_component by something is a unit.

Everything that is measure_with_unit_has_value_component by a measure_with_unit is a measure_value.

Every measure_with_unit measure_with_unit_has_value_component exactly 1 thing.
Everything that measure_with_unit_has_value_component something is a measure_with_unit.

Everything that is measure_with_unit_has_value_component by something is a measure_value.

Everything that is conversion_based_unit_has_conversion_factor by a conversion_based_unit is a measure_with_unit.

Every conversion_based_unit conversion_based_unit_has_conversion_factor exactly 1 thing.

Everything that conversion_based_unit_has_conversion_factor something is a conversion_based_unit.

Everything that is conversion_based_unit_has_conversion_factor by something is a measure_with_unit.

Модель GPT-5-mini:

- i101 is a measure_with_unit.
- i17 is a unit.
- i101_value_component is a measure_value.
- i101_value_component is a length_measure.
- i101 measure_with_unit_has_unit_component i17.
- i101 measure_with_unit_has_value_component i101_value_component.
- There is exactly 1 unit that i101 measure_with_unit_has_unit_component.
- There is exactly 1 measure_value that i101 measure_with_unit_has_value_component.
- i103 conversion_based_unit_has_conversion_factor i101.

Приложение 7

Большая смешанная выборка - 668 аксиом (фрагмент):

Everything that is colour_rgb_has_blue by a colour_rgb is a real.

i101 measure_with_unit_has_unit_component i17.

Everything that is view_volume_has_view_plane_distance by something is a length_measure.

i1 is an application_context.

i138_direction_ratios_1 is a list_of_real.

i15 is a shape_representation.

i100_direction_ratios_last is an emptylist_of_real.

i178_direction_ratios_3_value is a real.

i143 is a length_unit.

i160 is a document_representation_type.

Everything that product_concept_has_name something is a product_concept.

i177_direction_ratios_2 is a list_of_real.

Everything that is configuration_interpolation_has_next_configuration_definition by a configuration_interpolation is a configuration_definition.

Everything that concept_feature_relationship_has_description something is a concept_feature_relationship.

i142_luminous_intensity_exponent is a real.

Everything that is product_definition_context_role_has_name by a product_definition_context_role is a label.

i133_name is a label.

i176_name is a label.

i112 is an external_source.

i177_direction_ratios_2_value is a real.

i15_name is a label.

Every oriented_open_shell oriented_open_shell_has_open_shell_element exactly 1 thing.

Everything that is cylindrical_pair_range_has_upper_limit_actual_translation by a cylindrical_pair_range is a translational_range_measure.

Everything that is runout_zone_definition_has_orientation by something is a runout_zone_orientation.

i137_direction_ratios_2 is a list_of_real.

i138_name is a label.

i145_context_type is a text.

i148_frame_of_reference is a set_of_product_context.

i140_direction_ratios_3_value is a real.

Everything that pair_value_has_applies_to_pair something is a pair_value.

i139_direction_ratios_1 is a list_of_real.

i105 is a global_unit_assigned_context.

Everything that is concept_feature_relationship_has_description by a concept_feature_relationship is something that is a text or that is not something.

Every datum_target datum_target_has_target_basis_relationship exactly 1 thing.

i121 is a property_definition.

Everything that is attribute_classification_assignment_has_role by something is a classification_role.

i117_source is a label.

i145_coordinate_space_dimension is a dimension_count.

Everything that is geometric_tolerance_relationship_has_related_geometric_tolerance by a geometric_tolerance_relationship is a geometric_tolerance.

Everything that application_context_relationship_has_related_context something is an application_context_relationship.

Every process_product_association process_product_association_has_description exactly 1 thing.

Everything that action_directive_has_comment something is an action_directive.

Everything that curve_replica_has_parent_curve something is a curve_replica.

Everything that document_usage_constraint_has_subject_element something is a document_usage_constraint.

i151 is a product_definition_shape.

i149 is a product_definition_formation_with_specified_source.

i134 is an axis2_placement_3d.

i175_name is a label.

i113_description is a text.

i149_id is an identifier.

i138_direction_ratios_2 is a list_of_real.

Every concept_feature_relationship_with_condition concept_feature_relationship_with_condition_has_conditional_operator exactly 1 thing.

i105_coordinate_space_dimension is a dimension_count.

i178_direction_ratios_3 is a list_of_real.

i105 is a global_uncertainty_assigned_context.

i149_description is a text.

Everything that is action_resource_requirement_has_kind by something is a resource_requirement_type.

i175_coordinates_3_value is a length_measure.

Everything that is revolved_face_solid_has_axis by something is an axis1_placement.

...

Приложение 8

Промпт 1 - Answer with Attempto Controlled English. Show the axioms logically related to i101

Модель Anthropic Claude Sonnet 4.5:

Axioms Logically Related to i101

Direct Facts About i101

i101 is a length_measure_with_unit.

i101 measure_with_unit_has_unit_component i17.

i101 measure_with_unit_has_value_component i101_value_component.

Facts About i101's Components

i17 (unit component)

i17 is a si_unit.

i17 is a length_unit.

i17 is a named_unit.

i101_value_component (value component)

i101_value_component is a length_measure.

Facts About Entities Using i101

i103 (uses i101 as conversion factor)

i103 conversion_based_unit_has_conversion_factor i101.

i103 is a conversion_based_unit.

i103 is a length_unit.

i103 is a named_unit.

i103_name is a label.

General Axioms About measure_with_unit

Every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing.

Every measure_with_unit measure_with_unit_has_value_component exactly 1 thing.

Everything that measure_with_unit_has_unit_component something is a measure_with_unit.

Everything that measure_with_unit_has_value_component something is a measure_with_unit.

Everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit.

Everything that is measure_with_unit_has_unit_component by something is a unit.

Everything that is measure_with_unit_has_value_component by a measure_with_unit is a measure_value.

Everything that is measure_with_unit_has_value_component by something is a measure_value.

General Axioms About conversion_based_unit

Every conversion_based_unit conversion_based_unit_has_conversion_factor exactly 1 thing.

Everything that is conversion_based_unit_has_conversion_factor by a conversion_based_unit is a measure_with_unit.

Everything that is conversion_based_unit_has_conversion_factor by something is a measure_with_unit. Everything that conversion_based_unit_has_conversion_factor something is a conversion_based_unit.

General Axioms About Units

Everything that is an amount_of_substance_unit or that is an electric_current_unit or that is a length_unit or that is a luminous_intensity_unit or that is a mass_unit or that is a plane_angle_unit or that is a ratio_unit or that is a solid_angle_unit or that is a thermodynamic_temperature_unit or that is a time_unit or that is something that is a context_dependent_unit or that is a conversion_based_unit or that is a si_unit is a named_unit.

Every named_unit is something that is an amount_of_substance_unit or that is an electric_current_unit or that is a length_unit or that is a luminous_intensity_unit or that is a mass_unit or that is a plane_angle_unit or that is a ratio_unit or that is a solid_angle_unit or that is a thermodynamic_temperature_unit or that is a time_unit or that is something that is a context_dependent_unit or that is a conversion_based_unit or that is a si_unit.

Модель Qwen 3 Max:

Based on the knowledge base, here are the axioms logically related to i101:

Direct relationships involving i101:

- i101 measure_with_unit_has_unit_component i17
- i101 measure_with_unit_has_value_component i101_value_component
- i101 is a length_measure_with_unit
- i103 conversion_based_unit_has_conversion_factor i101

General axioms that apply to i101:

- Everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit
- Everything that is measure_with_unit_has_value_component by a measure_with_unit is a measure_value
- Every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing
- Every measure_with_unit measure_with_unit_has_value_component exactly 1 thing

Related definitions:

- i101_value_component is a length_measure
- i17 is a si_unit
- i17 is a length_unit
- i17 is a named_unit
- i103 is a length_unit
- i103 is a conversion_based_unit
- i103 is a named_unit

These axioms show that i101 is a length measure with unit, having i17 as its unit component and i101_value_component as its value component. It also serves as the conversion factor for i103, which is a conversion-based length unit.

Модель GPT-5-mini:

i101 is a length_measure_with_unit.

i101 measure_with_unit_has_unit_component i17.

i101 measure_with_unit_has_value_component i101_value_component.

i101_value_component is a length_measure.

i103 conversion_based_unit_has_conversion_factor i101.

Every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing.

Every measure_with_unit measure_with_unit_has_value_component exactly 1 thing.

Everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit.

Everything that measure_with_unit_has_unit_component something is a measure_with_unit.

Everything that measure_with_unit_has_value_component something is a measure_with_unit.

Everything that is conversion_based_unit_has_conversion_factor by a conversion_based_unit is a measure_with_unit.

Every conversion_based_unit conversion_based_unit_has_conversion_factor exactly 1 thing.

Промпт 2 - Answer with Attempto Controlled English. Draw logical conclusions based on the axioms regarding i101

Модель Anthropic Claude Sonnet 4.5:

Logical Conclusions about i101

Based on the given axioms, the following conclusions can be drawn about i101:

Direct Facts about i101

- i101 is a length_measure_with_unit.
- i101 is a measure_with_unit.
- i101 measure_with_unit_has_unit_component i17.
- i101 measure_with_unit_has_value_component i101_value_component.

Derived Conclusions about i101

- i101 has exactly 1 unit component (because every measure_with_unit measure_with_unit_has_unit_component exactly 1 thing).
- i101 has exactly 1 value component (because every measure_with_unit measure_with_unit_has_value_component exactly 1 thing).

- i101 is used as a conversion factor by i103 (because i103 conversion_based_unit_has_conversion_factor i101).

About i17 (the unit component of i101)

- i17 is a unit (because everything that is measure_with_unit_has_unit_component by a measure_with_unit is a unit).
- i17 is a si_unit.
- i17 is a length_unit.
- i17 is a named_unit.

About i101_value_component (the value component of i101)

- i101_value_component is a length_measure.
- i101_value_component is a measure_value (because everything that is measure_with_unit_has_value_component by a measure_with_unit is a measure_value).

About i103 (which references i101)

- i103 is a conversion_based_unit that uses i101 as its conversion factor.
- i103 is a length_unit.
- i103 is a named_unit.

Модель Qwen 3 Max:

Based on the axioms regarding i101, I can draw the following logical conclusions in Attempto Controlled English:

i101 is a length_measure_with_unit.
i101 has unit component i17.
i101 has value component i101_value_component.
i101_value_component is a length_measure.
i17 is a si_unit.
i17 is a length_unit.
i17 is a named_unit.
Every measure_with_unit has exactly 1 unit component.
Every measure_with_unit has exactly 1 value component.
Therefore i101 has exactly 1 unit component.
Therefore i101 has exactly 1 value component.
Every length_measure_with_unit is a measure_with_unit.
Therefore i101 is a measure_with_unit.

Модель GPT-5-mini:

i101 is a measure_with_unit.
i101_value_component is a measure_value.
i17 is a unit.
i17 is a named_unit.

Приложение 9

Пример одного из 66 текстовых документов с аксиомами - файл: s1-c5-214_10.txt:

i57 direction_has_direction_ratios i57_direction_ratios_1.

i173 is an axis2_placement_3d.

i165_name is a label.

i56_coordinates_3 is a list_of_length_measure.

i5 is a product.

i137_direction_ratios_1_value is a real.

i185_uncertainty is a set_of_uncertainty_measure_with_unit.

i39 is an object_role.

i113_description is a text.

i25_uncertainty is a set_of_uncertainty_measure_with_unit.

i40 document_representation_type_has_represented_document i33.

i98_direction_ratios_1 is a list_of_real.

i100_direction_ratios_2 is a list_of_real.

i35 is an applied_external_identification_assignment.

i88 product_definition_relationship_has_name i88_name.

i182 dimensional_exponents_has_mass_exponent i182_mass_exponent.

i100_direction_ratios_2 list_of_real_has_next i100_direction_ratios_3.

i4 application_protocol_definition_has_application i1.

i98_name is a label.

i110 product_definition_has_formation i109.

i25_units is a set_of_unit.

i185 is a global_unit_assigned_context.

i13 product_definition_has_id i13_id.

i180 direction_has_direction_ratios i180_direction_ratios_1.

i179_direction_ratios_3_value is a real.

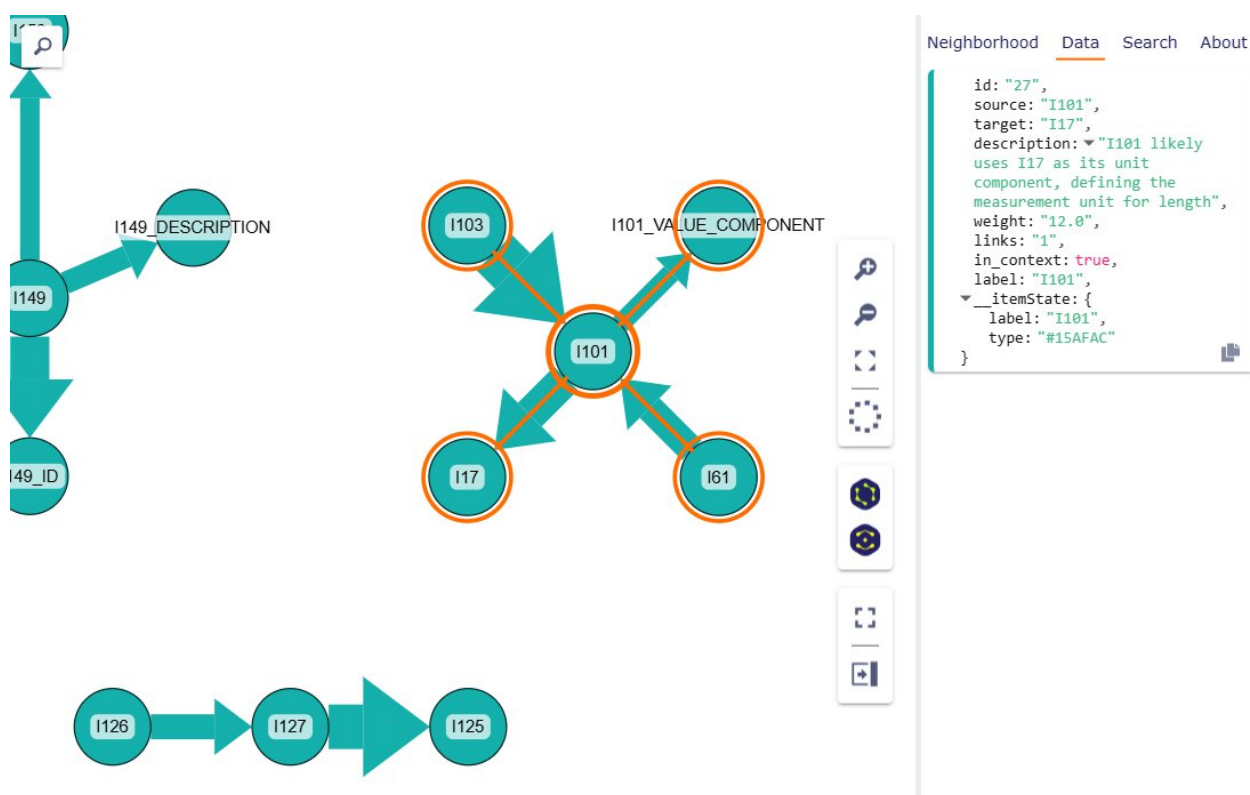
i184_description is a text.

i102_electric_current_exponent is a real.

Приложение 10

Визуализация извлечённого графа знаний

Граф извлечённых сущностей и связей по аксиомам связанным с объектом i101



Фрагмент полного графа сборки s1-c5-214

