

Aligning Active Inference Ontology to SUMO

Authors: David S. **Douglass**^{1,2} <https://orcid.org/0000-0001-7894-8019>; Adam **Pease**³ <https://orcid.org/0000-0001-9772-1266>; Daniel **Friedman**¹ <https://orcid.org/0000-0001-6232-9096>; Jessica **Balbuena**¹ <https://orcid.org/0000-0003-2741-4476>; Rhea **Chokhalingam**¹ <https://orcid.org/0009-0007-2061-3022>; Ana Magdalena **Hurtado**^{4,1} <https://orcid.org/0000-0003-4064-1876>; Maria Luiza **Iennaco**^{5,1} <https://orcid.org/0000-0002-5407-4852>; V. Bleu **Knight**¹ <https://orcid.org/0000-0002-9894-1989>; Scott Ryan **Maybell**^{6,1} <https://orcid.org/0000-0003-1612-5505>; Ali **Rahmjoo**¹ <https://orcid.org/0000-0002-3244-7419>; Paulo Duare Andrade **Sayeg**^{5,1} <https://orcid.org/0009-0006-0658-7684>; Jakub **Smékal**⁷ <https://orcid.org/0000-0003-4989-4968>; Dean **Tickles**^{8,1} <https://orcid.org/0000-0003-2213-0773>; Alex **Vyatkin**¹ <https://orcid.org/0000-0003-1306-4620>

1 Active Inference Institute

2 American Society for Cybernetics

3 Naval Postgraduate School

4 Arizona State University

5 University of São Paulo

6 University of Oxford

7 Stanford University

8 Professional Initiatives Programming

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Contact: DavidSDouglass@ActiveInference.Institute

ABSTRACT

Active Inference and its associated concepts (notably predictive coding, predictive processing, and the Free Energy Principle) act instrumentally as a conceptual system that provides structure to a large and growing number of scientific and humanistic fields; and realistically as candidate real-world properties and their mutual affordances.

In 2021, the Active Inference Institute adopted SUMO, the Suggested Upper Merged Ontology, as the ontology with which to map its inventory of topics and their interrelations, along with the corresponding multilingual technical terms.

This document aims to act as a scaffolding, displaying a tentative alignment of Active Inference terms with SUMO entities, in order to facilitate the anticipated process of rigorously mapping Active Inference to SUMO. For a subset of Active Inference terms, we identify published SUMO files (i.e. .kif files) likely to contain correctly delineated mappings of those topics; likely SUMO supersets of the desired targets; some exemplary SUMO subsets of the targets; and indications of relationships among the identified SUMO topics.

KEYWORDS: Active Inference Ontology, SUMO Ontology

OUTLINE OF CONTENTS

1. Notes on Presentation of Active Inference Data.

2. Notes on Presentation of SUMO Data.

3. An “alignment” table. This shows, for many core terms used in the Active Inference Ontology, areas of SUMO that are likely to contain corresponding topics; or which are portions of SUMO where topics should be created to more nearly match Active Inference concepts.

1. Notes on Presentation of Active Inference Data.

Some of the following items occur only in the external full table of alignments of Active Inference to SUMO, i.e. “Active Inference Topics Aligned to SUMO.xlsx”

Concept. A concept is a persisting process of reproducing (copying, rehearsing, ...) a relation, either perfectly or with constrained mutation. See Pask and Scott (1973).

Topic. A topic is a shared *concept*. Distinguished from *term*.

Term. A term is a linguistic artifact, written or spoken, in a specific natural or formal language, used to indicate (activate, represent, ...) a *topic*.

Module. Active Inference topics are grouped into a small number of modules (also called sub-theories or subontologies). These are high-level clusters of topics that show a high degree of inter-definition, interdependence, and collocation in texts. In a typical course, members of a module would taught together.

As of 2024, the inventory of modules in the Active Inference ontology is rather informal. The module, with some of their notable members, are:

Action Action Planning, Action Prediction, Agency, Behavior, Policy, Policy selection, Preference

Agents in the Niche Affordance, Agent, Cognition, Culture, Ensemble, Generative Model, Generative Process, Narrative, Niche, Non-Equilibrium Steady State, Particle, Recognition Model...

Bayesian Statistics Accuracy, Ambiguity, Bayes Theorem, Bayesian Inference, Belief, Belief updating, Complexity, Data, Expectation, Inference, Information, Learning, Outcome, Posterior...

Free Energy Active Inference, Epistemic value, Expected Free Energy, Free Energy Principle, Generalized Free Energy, Pragmatic Value, Process Theory, Variational, Variational Free Energy

Information Cue, Information Geometry

Markov Partitioning Active States, Blanket State, External State, Friston Blanket, Hidden State, Internal State, Markov Blanket, Markov Decision Process, Sense State

Perception Attention, Evidence, Novelty, Observation, Regime of Attention, Saliency

Systems Hierarchical Model, Living system, Multi-scale system

List. Each individual topics has been assigned to one of three “lists.” This is a porous partition, created to help organize exposition.

Core topics should be mastered in a general course in Active Inference concepts, aimed at upper-division college undergraduates in technical curricula.

A textbook might spend from half a page to one section of a chapter, on each core topic.

Omitting or failing to master a core topic can be regarded as a failure of presentation or learning.

Each *entailed* topic is essential to understanding at least one core topics. An instructor or textbook author can assume that some of these topics are already understood by a typical adequately-prepared student. Nonetheless, usage of each entailed topic should be indicated, i.e. “defined,” in at least as much detail as is typically found in a technical glossary in a textbook or review article. Source: Definitions of core terms.

Supplemental topics define notions typical of “extra credit” or “advanced topics” material. As conceived by the Active Inference Ontology working group, adding a supplemental topic to a presentation expands the scope of ideas covered, but need not be considered essential to mastery of Active Inference and its major cohorts (notably Predictive Process and the Free Energy Principle).

Definitions. We restrict ourselves to two senses or three senses of a given topic name. Deeper examination may show that some of these “senses” should be separated into distinct topics (which may be analogs of one another).

Expositions. The best single source for understanding Active Inference is textbook “Active Inference: The Free Energy Principle in Mind, Brain, and Behavior” by Thomas Parr, Giovanni Pezzulo, and Karl J. Friston (2022, MIT Press). This work is accessible online at <https://direct.mit.edu/books/oa-monograph/5299/Active-InferenceThe-Free-Energy-Principle-in-Mind>

A suitable instructor-run course might run for half a year. An example is the online course “Active Inference Textbook Group,” anchored in Parr, Pezullo, Friston.

Two presentations of this course are viewable at

<https://www.youtube.com/watch?v=G9GfOMjF4g0&list=PLNm0u2n1Iwdob1pSM1q9yzDboE3uvQqq-> and
https://www.youtube.com/watch?v=3U8AXcIaUFI&list=PLNm0u2n1Iwdpm1wcq9DOGSdKDDvnEt_xG

2. Notes on Presentation of SUMO Data.

(1) **General remarks.** A 2001 overview of SUMO can be found at <https://www.adampease.org/FOIS.pdf>

Unlike taxonomies or knowledge graphs, SUMO concepts are defined axiomatically in SUMO. The identifiers mean only what their formal axioms say that they mean in mathematical logic, without recourse to human interpretation. The existing set of 100,000 formal statements can be added to in order to define additional terms specific to any domain.

A playlists of Adam Pease's videos, discussing "how to do SUMO," appears at

https://www.youtube.com/watch?v=SkruXPmN0kk&list=PLpBQIgki3izcrbaiuOH_OWWguY_duSumA&ab_channel=OntologyTalkwithAdamPease

(2) **Class and relation names.** SUMO identifiers use the convention of CamelCase. Relations that are not functions have an initial lowercase letter. All other identifiers begin with an uppercase letter. Sumo variable names are prefixed with “?”.

In this document, we often flag terms that do not yet belong to SUMO by prefixing an asterisk (as in “*ActiveState”).

(3) **Column “SUMO superclass, instanceOf, superrelation.”** In the tables aligning Active Inference to SUMO terms (both the full table presented separately and the excerpt below), this column situates a conceptual entity in the whole SUMO ontology by showing the term’s place one or more “upward” or “including” or contextual or more-general relationships:

superclass. (A neologism introduced in this present document.) See the inverse of superclass, i.e. “*subclass*,” below.

instanceOf. SUMO describes the instance relation as follows: "An object is an [instance](#) of a [Class](#) if it is included in that [Class](#). An individual may be an [instance](#) of many classes, some of which may be subclasses of others. Thus, there is no assumption in the meaning of [instance](#) about specificity or uniqueness."

superrelation. (A neologism introduced in this present document.) See the inverse of superrelation, i.e. “*subrelation*,” below.

(4) **Column “SUMO subclasses, subrelations.”** This refines the reader’s appreciation of a SUMO entity name, by giving terms that are “included-in” or less-general than the named target entity: *Subclass.* The subclass relation resembles the word “subset” (as used common parlance to show relations among concepts, e.g. by means of Venn diagrams), but there is no arbitrariness, nor exceptions to inheritance: The attributes and relations of a superclasses are inherited by their subclasses.

SUMO describes the subclass relation as follows: "' CLASS1 is a [subclass](#) of CLASS2' means that every [instance](#) of CLASS1 is also an [instance](#) of CLASS2. A [Class](#) may have multiple superclasses and subclasses."

subrelation.

SUMO describes the subrelation relation as follows: "'REL1 is a [subrelation](#) of REL2' means that 'every tuple of REL1 is also a tuple of REL2.' In other words, if the [Relation](#) REL1 holds for some arguments arg_1, arg_2, ... arg_n, then the [Relation](#) REL2 holds for the same arguments.

A consequence of this is that a [Relation](#) and its subrelations must have the same number of arguments." One further consequence is to distinguish some specific subrelations from relevant *metaphorical* relations (in which an argument in the target of the metaphor may range freely across possible values without invalidating the statement of metaphoricality).

(5) Column “Domains.” This column breaks down a relation that’s relevant to the Active Inference term in question, by going through the related terms, and stating the domain (type, class) of each “term of the relation,” from first onward.

SUMO describes the *domain* relation as follows: "Provides a computationally and heuristically convenient mechanism for declaring the argument types of a given relation. The formula ([domain](#) REL INT CLASS) means that the INT'th element of each tuple in the relation REL must be an instance of CLASS. Specifying argument types is very helpful in maintaining ontologies. Representation systems can use these specifications to classify terms and check integrity constraints. If the restriction on the argument type of a [Relation](#) is not captured by a [Class](#) already defined in the ontology, one can specify a [Class](#) compositionally with the functions [UnionFn](#), [IntersectionFn](#), etc.")

(6) Column “Other SUMO relations.” This column states a variety of relations among SUMO topics and terms. Sometimes the intention is simply to motivate the suggested alignment with Active Inference.

3. SELECTED ACTIVE INFERENCE TOPICS ALIGNED WITH SUMO CLASSES AND RELATIONS

Topic	Module	Proposed Definition 1	Proposed Definition 2	SUMO superclass, instanceOf, superrelation	Domains, Roles	Other SUMO relations
abstractCounterpart		(abstractCounterpart ?AB ?PHYS) relates a Physical entity to an Abstract one which is an idealized model in some dimension of the Physical entity.	Example: an Abstract GraphNode could be stated to be the counterpart of an actual Computer in a ComputerNetwork.	abstractCounterpart is a subrelation of represents. abstractCounterpart is an instance of binary predicate.	The number 1 argument of abstractCounterpart is an instance of abstract. The number 2 argument of abstractCounterpart is an instance of physical.	
Accuracy	Bayesian Statistics	Broad sense: how “close to the mark” an Estimator is.	Narrow sense: the expected or realized extent of Surprise on an estimation, usually about Sense State reflecting the Recognition density	*Accuracy is a subclass of PsychologicalAttribute	An instance of *Accuracy is the number 2 argument of abstractCounterpart.	*Accuracy is internally related to TruthValue
Action	Action	Broad sense: The dynamics, mechanisms, and measurements of Behavior	Narrow sense: The sequence of Active States enacted by an Agent via Policy selection from Affordance	*AbstractAction is a subclass of IntentionalProcess.		
Action Planning	Action	The selection of an Affordance based upon Inference of Expected Free Energy		Planning is a subclass of IntentionalPsychologicalProcess.		
Action Prediction	Action	Inference on current and future Expectation of Action				Predicting is a subclass of intentional psychological process
Active				actionTendency is an instance of binary relation.	The number 1 argument of actionTendency is an instance of emotional state. The number 2 argument of actionTendency is a subclass of emotional behavioral process.	@active is internally related to actionTendency.
Active Inference	Free Energy	Active Inference is a Process Theory related to Free Energy Principle.		Judging is a subclass of Selecting		*ActiveInference is internally related to Judging.
Active States	Markov	In the Friston Blanket				*ActiveState is a

	Partitioning	formalism, the Blanket State are the Sense State (incoming Sensory input) and Active States (outgoing influence of Policy selection)				subclass of PhysiologicProcess.
Active Vision		refers to the process of visual perceptions, in terms of oculomotor Sensorimotor Behavior and Cognitive System Generative Model	refers to regime of visual perceptions through dynamical perturbations of light over the retina. As if feeling the textured light reflected off the niche surfaces	Looking is a subclass of intentional process. Searching is a subclass of investigating.		*ActiveVision is a subclass of Looking. *ActiveVision is a subclass of Searching.
Affordance	Agents in the Niche	Options or capacities for Action by an Agent (sometimes called "Affordance 3.0")	From Ecological Psychology, the Perception of a possibility for Action (sometimes called "Affordance 2.0").	resource is an instance of CaseRole. resource is a subrelation of patient.	resource is an instance of case role. resource is a subrelation of patient.	*Affordance is equivalent to resource.
Agency	Action	The ability of an Agent to engage in Action in their Niche and enact Goal-driven selection or Policy selection based upon Preference		Intentional process is a subclass of process		*Agency is internally related to IntentionalProcess
Agent	Agents in the Niche	Entity as modeled by Active Inference, with Internal State separated from External State by Blanket State		agent is a subrelation of involvedInEvent. agent is an instance of case role.	The number 1 argument of agent is an instance of Process. The number 2 argument of agent is an instance of AutonomousAgent.	A SentientAgent is an Agent that is capable of Perception and experiences some level of consciousness.
Ambiguity	Bayesian Statistics	Broad sense: Extent to which stimuli have multiple plausible interpretations, requiring priors &/or Action for disambiguation	Narrow sense: Specific model parameter used to model Uncertainty, usually about sensory Perception.	*Ambiguity is a subclass of StateOfMind.		
Attention	Perception	Broad sense: Generative Model that is aware of some Stimulus, reflected by its Saliency	Narrow sense: Attention modulates the confidence on the Precision of Sense State, reflecting Sensory input	*Attention is a subclass of IntentionalProcess.	*Attention nominalizes the attends CaseRole	
Autopoiesis		Phenomena of a System that recapitulates the		*Autopoiesis is internally related to Relication.		

		material and informational causes of its own composition/existence.		Replication is a subclass of OrganismProcess.		
Bayesian Inference	Bayesian Statistics	As opposed to frequentist analysis, Bayesian Inference uses a specified Prior or Empirical prior to Update the distributional Posterior		*BayesianInference is a subclass of PhysiologicProcess.		
Behavior	Action	The sequence of Action that an Agent is observed to enact.				*Behavior is an near synonym of BodyMotion. *Behavior is an near synonym of Process.
Belief	Bayesian Statistics	Broad sense: Felt sense by an Agent of something being true, or confidence it is the case.	Narrow sense: the State of a Random variable in a Bayesian Inference scheme.	*Belief is a subclass of PsychologicalProcess. Believes is an instance of PropositionalAttitude.		
Belief updating	Bayesian Statistics	Belief updating is changes in a Bayesian Inference Belief through time.		*BeliefUpdating is a subclass of IntentionalPsychologicalProcess. IntentionalPsychologicalProcess is a subclass of IntentionalProcess.		
Blanket State	Markov Partitioning	Set of states in the Markov Blanket Partition that make Internal State and External State have Conditional Probability that are independent.		*ThermodynamicBlanketStates are PhysicalStates. *HomeostaticBlanketStates are InternalAttribute.		
Cognition	Agents in the Niche	An Agent modifying the weights of its Internal State for the purpose of Action Planning and/or Belief updating. (This is a @realistCounterpart of		CognitiveAgent is a subclass of SentientAgent		A CognitiveAgent is an Agent that has the ability to reason, deliberate, make plans, and experience emotions.

		Goal-driven selection.)				
Complexity	Bayesian Statistics	The extent to which an Agent must revise a Belief to explain incoming Sensory observations.	The Kullback-Leibler Divergence between the Prior and Posterior which is used in Bayesian model selection to find the simplest (least complex) model and avoid overfitting on the noise inherent in Sensory observations.	*Complexity is a subclass of ObjectiveNorm.		
Cue	Information	A Stimulus, event, object, or Guidance signal that serves to guide Behavior, such as a retrieval cue, or that acts as a @Signal to the presentation of another stimulus, event, or object, such as an unconditioned stimulus or reinforcement. (dictionary.apa.org)				A *Cue is internally related to an instance of Perception. AgentPatientProcess is a subclass of Process.
Culture	Agents in the Niche	Culture is the Niche for social Agent, that structures their Regime of Attention		*Culture is a subclass of Proposition.		
Data	Bayesian Statistics	Data are a set of values of qualitative or quantitative variables about one or more Agent or object.		InformationMeasure is a subclass of ConstantQuantity. Stating is a subclass of LinguisticCommunication. UnitOfInformation is a subclass of NonCompositeUnitOfMeasure	The number 1 argument of ContainsInformation is an instance of ContentBearingPhysical.	*Data is a near synonym of InformationMeasure. *Data is a near synonym of FactualText. *Data is a near synonym of Stating. Content bearing object is internally related to contains information. Content bearing physical is a subclass of physical.
Decision-making		Within Active Inference, this is the same as Policy selection		Deciding is a subclass of Selecting.		

				Selecting is a subclass of IntentionalPsychologicalProcess.		
Ensemble	Agents in the Niche	Group of more than one Agent.		*Ensemble is a subclass of Collection		
Epistemic value	Free Energy	Epistemic value is the value of Information gain or Expectation of reduction in Uncertainty about a State with respect to a Policy, used in Policy selection		*EpistemicValue is a subclass of PsychologicalProcess. *EpistemicValue is a subclass of SubjectiveAssessmentAttribute. *EpistemicValue is an instance of InternalAttribute		The abstract counterpart of an *EpistemicValue is an *AbstractEpistemicValue. *EpistemicValue is a relatedInternalConcept to Investigating.
Evidence	Perception	Data as recognized and interpreted by Generative Model of Agent		*Evidence is internally related to IntentionalPsychologicalProcess.		
Expected Free Energy	Free Energy	Measure for performing Inference on Action over a given time horizon (Policy selection, Action and Planning as Divergence Minimization).	The two components of Expected Free Energy are the imperative to satisfy Preferences, and the penalty for failing to minimize Expectation of Surprisal.	*ExpectedFreeEnergy is a subclass of RelationalAttribute.		*ExpectedFreeEnergy is internally related to InformationMeasure.
External State	Markov Partitioning	States with r_{65} independent from Internal State, conditioned on Blanket State.		*ExternalState is a subset of PhysiologicProcess.		
Free Energy	Free Energy	Free Energy is an Information Theoretic quantity that constitutes an upper bound on Surprisal.	Free Energy can refer to various or multiple subtypes of Free Energy: * Variational Free Energy * Expected Free Energy * Free Energy of the Expected Future * Helmholtz Free Energy	*FreeEnergy is a subclass of PhysicalDimension. *FreeEnergy is a subclass of RelationalAttribute.		*FreeEnergy is internally related to InformationMeasure.

Free Energy Principle	Free Energy	A generalization of Predictive Coding (PC) according to which organisms minimize an upper bound on the Entropy of Sensory input (or sensory signals) (the Free Energy). Under specific assumptions, Free Energy translates to Prediction error.	A set of statistical principles that describe how Agents can maintain their self-organization in the face of random fluctuations from the environment.	*FreeEnergyPrinciple is an instance of Proposition.		
Friston Blanket	Markov Partitioning	Markov Blanket with partitioned Active States and Sense State.		*FristonBlanket is a subclass of ProbabilityRelation. *FristonBlanket is a subclass of Proposition.		
Generalized Free Energy	Free Energy	Past Variational Free Energy plus future Expected Free Energy (each totaled over Policy).		*GeneralizedFreeEnergy is a subclass of ProbabilityRelation. *GeneralizedFreeEnergy is a subclass of Proposition.		
Generative Model	Agents in the Niche	A formalism that describes the mapping between Hidden State, and Expectations of Action Prediction, Sensory outcome.	Recognition Model Update Internal State parameter that correspond to External State (including Hidden State causes of environment states), Blanket State, and Internal State (meta-modeling). In contrast, Generative Model take those same Internal State parameter Estimator and emit expected or plausible observations.	*GenerativeModel is a subclass of Process.		
Generative Process	Agents in the Niche	Underlying @dynamical process in the Niche giving rise to Agent Observation and @agent Action Prediction.	Enactive ecological process using morphological computing processes where the Niche Regime of	*GenerativeProcess is a subclass of ProbabilityRelation. *GenerativeProcess is a		

			Attention @morphogenesis and generative model interact to create an embodied learning dynamic.	subclass of Proposition. *GenerativeProcess is a subclass of Process.		
Hidden State	Markov Partitioning	Unobserved variable in Bayesian Inference, can reflect a Latent cause.		*AbstractHiddenState is a subclass of ProbabilityRelation.		
Hierarchical Model	Systems	A hierarchy of Estimators, which operate at different spatiotemporal timescales (so they track features at different scales); all carrying out Predictive Processing		*HierarchicalModel is a subclass of ProbabilityRelation. *HierarchicalModel is a subclass of Proposition. *HierarchicalModel is a subclass of Process.		
Inference	Bayesian Statistics	Process of reaching a (local or global) conclusion within a Model, for example with Bayesian Inference.	The process of using a Sensory observation (observed variable, data) along with a known set of parameters to determine the state of an unknown, Latent cause (unobserved variable).	*AbstractInference is a subclass of Learning. (This looks wrong. Abstract classes are non-temporal, and Learning changes across time.)		
Information	Bayesian Statistics	Measured in bits, the reduction of Uncertainty on a Belief distribution of some type. Usually Syntactic (Shannon) but also can be Semantic (e.g. Bayesian).				*Information is internally related to InformationMeasure.
Internal State	Markov Partitioning	States with #r65 independent from External State, conditioned on Blanket State.		*InternalState is a subset of PhysiologicProcess.		
Learning	Bayesian Statistics	Broad sense: Process of an Agent engaged in Updates to Cognition (and possibly) Behavior.	Narrow sense: Process of Bayesian Inference where Generative Model parameters undergo Belief updating	Learning is a subclass of intentional psychological process		

Living system	Systems	Agent engaged in Autopoiesis				*Attractor is internally related to SubjectiveAssessmentAttribute.
Logic						Logical operator is a subclass of predicate
Markov Blanket	Markov Partitioning	Markov Partitioning Model of System, reflecting Agent as delineated from the Niche via an Interface. The Markov Blanket State reflect the State(s) upon which Internal State and External State are conditionally independent.		*ThermodynamicSystem is a subclass of *System		
Markov Decision Process	Markov Partitioning	Bayesian Inference Model where Agent Generative Model can implement Policy selection on Affordances reflected by Active States, while other features of the Generative Process are outside the Control (states) of the Agent.		Deciding is a subclass of Selecting		
Niche	Agents in the Niche	Ecology System constituting the Generative Process (as Partitioned from the Agent who instantiates a Generative Model).				Attribute subsumes *Niche.
Non-Equilibrium Steady State	Agents in the Niche	Technically, a Non-Equilibrium Steady State requires a solution to the Fokker Planck equation (i.e., density dynamics). A nonequilibrium steady-state solution entails solenoidal (i.e., conservative or divergence free)	Generally, a Non-Equilibrium Steady State refers to a System with dynamics that are unchanging, or at Stationarity in some State.	*NonEquilibriumSteadyState is a subset of Attribute.		

		dynamics that break detailed balance (and underwrite stochastic chaos).				
Novelty	Perception	The Internal State assumed by an Agent's epistemic Affordance, when unable to immediately (e.g. locally) resolve Uncertainty about the contingencies, i.e. the opportunity to resolve Uncertainty about "what would happen if I did that?"		*Novelty is a subclass of SubjectiveAssessmentAttribute. SubjectiveAssessmentAttribute is a subclass of NormativeAttribute		
Observation	Perception	The Belief updating of an Internal State registered by a Sensory input, given the weighting assigned to that class of input in comparison with weighting of the competing Priors. (This is a narrow sense of "observation," where the Agent is "looking for this kind of input.")	Any Sensory input, either discrete-valued or continuous-valued. (This is a broad sense.)			*Observation is internally related to CognitiveAgent.
Perception	Perception	Posterior State Inference after each new Observation.		Perception is a subclass of psychological process		
Policy	Action	Sequence of Actions, reflected by series of Active States as implemented in Policy selection which is Action Prediction or Action and Planning as Divergence Minimization		Policy is a subclass of Proposition.		
Posterior	Bayesian Statistics	The Update to the Prior after Observation has occurred	In Bayes' theorem, the Posterior is equal to the product of the Likelihood and Prior divided by the model evidence.	*Posterior is a subclass of Proposition.		
Pragmatic	Free	Pragmatic Value is the	Pragmatic value	*PragmaticValue is a		*PragmaticValue is a

Value	Energy	benefit to an organism of a given Policy or Action, measured in terms of probability of a Policy leading to Expectation of Random variable values that are aligned with the Preference of the Agent	describes the extent to which a given action is aligned with rewarding preferences over sensory outcomes.	subclass of StateOfMind.		relatedInternalConcept to Selecting.
Principle		Principle		*Principle is an instance of Proposition.		*Principle is internally related to Reasoning. Reasoning is an instance of Propositional Psychological Process
Propositional attitude				attitudeForFormula is an instance of ternary relation.	The number 1 argument of attitudeForFormula is an instance of EmotionalState. The number 2 argument of attitudeForFormula is an instance of agent. The number 3 argument of attitudeForFormula is an instance of Formula.	
Recognition Model	Agents in the Niche	Recognition Model is the kind of Model that affords Variational Inference, which lets us calculate or approximate a probability distribution. Recognition Model is a synonym for Variational Model.	In Dayan and Abbot (2001), the probability of a Hidden State (causes) given Sensory Data (effects) under some parameter.	Recognition Model is a subclass of Modeling. Modeling is a subclass of intentional process		*Recognition is internally related to Realization. Recognition Model is internally related to Variational.
Representation	Agents in the Niche	A structural correspondence between some Random variable inside a System and some Random variable outside the System (isomorphism being the strongest kind of		represents is a subrelation of refers.	refers is a relation from an Entity to an Entity.	* If a process is an instance of expressing and an agent is an agent of the process, * then there exists an attribute such that the attribute is an instance of state of mind and the

		correspondence), such that the System engages in Inference carried out by the System maintains the correspondence				attribute is an attribute of the agent and the process represents the attribute
represents		SUMO relation (represents ?THING ? ENTITY) means that ? THING in some way indicates, expresses, connotes, pictures, describes, etc. ?ENTITY. The Predicates contains Information and realization are subrelations of represents.		represents is an instance of binary predicate. represents is a subrelation of refers.	The number 1 argument of refers is an instance of Entity. The number 2 argument of refers is an instance of Entity.	
Sense State	Markov Partitioning	In the Friston Blanket formalism, the Blanket State are the Sense State (incoming Sensory input) and Active States (outgoing influence of Policy selection)		*SenseState is a subset of PhysiologicProcess		
State	Bayesian Statistics	is the statistical, computational, or mathematical value for a parameter within the State space of a Model.		Attribute is a subclass of abstract.		"State" is a near synonym of Attribute.
State space	Bayesian Statistics	Set of variables/parameters that describe a System.	A state space is the set of all possible configurations of a system	*StateSpace is a subset of Attribute		
System	Systems	Set of relations described by State space of a Model.	Differentiable and Integratable in terms of Variables and functions.	*System is a subclass of Agent		

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REFERENCES

Douglass, David S. et al. (2024). *Active Inference Topics Aligned to SUMO*. DOI 10.5281/zenodo.11459323

Douglass, David S. et al. (2024). *Aligning Spatial Web Terminology to SUMO*. <https://zenodo.org/doi/10.5281/zenodo.11055372>

Pask, Gordon and Bernard C.E. Scott (1973). *CASTE: A System for Exhibiting Learning Strategies and Regulating Uncertainties*. *Int. J. Man-Machine Studies* (1973) 5, 17-52.
<https://www.sciencedirect.com/science/article/abs/pii/S0020737373800082?via%3Dihub>

Niles, I., & Pease, A., (2001). *Toward a Standard Upper Ontology*, in *Proceedings of the 2nd International Conference on Formal Ontology in Information Systems (FOIS-2001)*, Chris Welty and Barry Smith, eds, pp 2-9. <https://dl.acm.org/doi/10.1145/505168.505170>

Pease, A., (2011). *Ontology: A Practical Guide*. Articulate Software Press, Angwin, CA. ISBN 978-1-889455-10-5

Pease, Adam (2024). *Suggested Upper Merged Ontology (SUMO)*. <https://ontologyportal.org/>