NEOPLASMS - *Melanoma* (C43-C44) Ontology

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1 Ontology Logic

Our ontology logic is the *Substitution Logic* with its underlying monadic machinery [1–7], and it is in progress of being implemented as a namespace category embraced by the .NET Framework Class Library. We frequently say '.NET' instead of '.NET Framework', and the version presently used is the .NET Framework 4.

The namespace is called *Namespace SubstitutionLogic*. Our coding and implementation fragments and examples in this document will follow the substitution logic notation, and for .NET encoding examples we use the Microsoft.VisualBasic namespace, and therefore the Visual Basic (VB) language. This by no means excludes use of other .NET languages like C♯ or F♯. The overall objective in our ontology logic documentation is to reach maximum readability and transparency regardless of readers being well or less versed in logic and programming.

Substitution logic is not *one single* logic, but an environment of logics including first-order, equational and type theoretic styles of logic. One of the main advantages of the substitution logic environment is, on the one hand, the flexibility to choose particular logics, and, on the other hand, to enable transformations between these logics. Roughly speaking, one professional group or public authority may prefer to implement vocabulary and inference principles in one logic, another group or authority prefers another logic, yet, they are required to be able to communicate. Substitution logic morphisms are designed to fulfill these needs and requirements in that they enable and empower communication and interoperability.

Substitution logic is the object language conceptually defined as a *monadic extensions* of general logic [8], and this object language is conceptually developed entirely using the language of *category theory* (CT) as its metalanguage. Category theory in turn as an object language is assumed to use *Zermelo-Fraenkel's Set Theory* (ZFC) as a metalanguage. ZFC in turn is assumed to build upon generally accepted developments in the *foundations of mathematics*, as historically developed e.g. by Frege, Peano, Hilbert, Zermelo, Fraenkel, Gödel and Schönfinkel.

1.1 SIGNATURE

In this version we still restrict to using general diagnosis encoding together with some specific typing as provided in the AJCC Cancer Staging Manual [9].

SNOMED CT terminologies can be included into sorts and operators, so that e.g. "Melanoma in situ of face" as a constant of type `disorder` would be included. However, SNOMED CT for melanoma contains mainly disorder terms, which then overlap with diagnosis encoding, and they have therefore still not been included, since it only leads to mapping requirements for diagnosis and disorder codes and thus not add anything essential into other parts of the melanoma logic. Observable entities, findings, morphologic abnormalities, and procedures do exist, like "Clark's melanoma level" and "Breslow depth staging for melanoma" of type `observable_entity`, "Clark melanoma level ..." of type `finding`, and "Excision of melanoma" of type `procedure`, but the scope is incomplete e.g. as compared with terminology found in the AJCC Cancer Staging Manual and melanoma clinical guidelines.

A major issue then about these types is really what are the constants and operators question about

1.1.1 Sorts Similar to most programming languages, .NET languages also provide built-in data types. In the Common Type System of the .NET Framework, these are called value types. Value types are also the user-defined types and the enumerations.

1.1.2 Operators

1.2 VOCABULARY AND MEANING

1.2.1 Terms

1.2.2 Algebras algebra may be built-in to the .NETFramework, like the `DateAndTime`.

1.3 STATEMENTS AND REASONING

1.3.1 Sentences

1.3.2 Logical consequence and satisfaction relations

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3 Melanoma Ontology logic specifications

Each stakeholder maintains their own logic. Different stakeholder logics may overlap, but more important is the existence, on the one hand, of logic morphisms between stakeholder logics, and, on the other hand, of suitable limits and colimits of stakeholder logics enabling various kind of crosspoint and superseding logics, respectively.

3.1 Ontology logic specification: Secondary care

SIGNATURE		VOCABULARY AND MEANING		STATEMENTS AND REASONING	
Sorts	**Operators**	**Terms**	**Algebras**	**Sentences**	**Logical consequence and satisfaction relations**
		basic logic with given sorts and without type constructors			
$\Sigma = (S, \Omega)$		$\mathsf{T}_\Sigma\{X_\mathtt{s}\}_{\mathtt{s}\in S}$	$\mathfrak{A}_\Sigma$	$\mathsf{Sen} = \dots$	$\vdash_\Sigma \models_\Sigma$
`t`	ω		$\mathfrak{A}_\Sigma(\mathtt{t}), \mathfrak{A}_\Sigma(\omega)$		
`nat`	ω		$\mathfrak{A}_\Sigma(\mathtt{nat})$ is the .NET Integer Data Type (Visual Basic).		
`DateAndTime`	ω		$\mathfrak{A}_\Sigma(\mathtt{DateAndTime})$ is the namespace Microsoft.VisualBasic DateAndTime class including its Methods and Properties.		
`DateAndTimeSpan`	ω		$\mathfrak{A}_\Sigma(\mathtt{t}), \mathfrak{A}_\Sigma(\omega)$		
$S = \{$`ICD−10`,	$\Omega = \{\dots, \mathtt{C43}, \dots, \mathtt{C43.5}, \dots :\longrightarrow \mathtt{ICD{-}10}$,		$\mathfrak{A}_\Sigma(\mathtt{ICD{-}10}) = \dots$		
`ICD−O−3`,	$\dots 8721/3, \dots :\longrightarrow \mathtt{ICD{-}O{-}3}$,		$\mathfrak{A}_\Sigma(\mathtt{ICD{-}O{-}3}) = \dots$		
`ILDS`,	$\dots, \mathtt{C43.L10}, \dots :\longrightarrow \mathtt{ILDS}$,		$\mathfrak{A}_\Sigma(\mathtt{ILDS}) = \dots$		
`TypeOfMelanoma`,	$\mathtt{SSM}, \mathtt{NM}, \mathtt{LMM}, \mathtt{ALM} :\longrightarrow \mathtt{TypeOfMelanoma}$,		$\mathfrak{A}_\Sigma(\mathtt{TypeOfMelanoma}) = \{SSM, NM, LMM, ALM\}$		
`T`,	$\mathtt{T0}, \dots$		$\mathfrak{A}_\Sigma(\dots) = \dots$		
`N`,	$\mathtt{N0}, \dots$		$\mathfrak{A}_\Sigma(\dots) = \dots$		
`M`,	$\mathtt{M0}, \dots$		$\mathfrak{A}_\Sigma(\dots) = \dots$		
`Stage`$\}$	$\mathtt{ERROR}, \mathtt{UNK}, \mathtt{0}, \mathtt{IA}, \mathtt{IB}, \mathtt{IIA}, \mathtt{IIB}, \mathtt{IIC}, \mathtt{IIIA}, \mathtt{IIIB}, \mathtt{IIIC}, \mathtt{IIINOS}, \mathtt{IV} :\longrightarrow \mathtt{Stage}\}$		$\mathfrak{A}_\Sigma(\mathtt{Stage})$ is in .NET implemented as an Enumeration in the Common Type System.		
		$x \in X_\mathtt{s}$			
	`C43.5` $:\longrightarrow$ `ICD−10`	`C43.5`	$\mathfrak{A}_\Sigma(C43.5) = C43.5 \in \mathfrak{A}_\Sigma(\mathtt{ICD{-}10})$		
		$x \in X_\mathtt{TypeOfMelanoma}$	$\mathfrak{A}_\Sigma(x) = NM \in \mathfrak{A}_\Sigma(\mathtt{TypeOfMelanoma})$		
	`AJCC_TNM_7_Stage` : $\mathtt{T} \times \mathtt{N} \times \mathtt{M} \longrightarrow \mathtt{Stage}$	$\mathtt{AJCC\_TNM\_7\_Stage}(x_\mathtt{T}, x_\mathtt{N}, x_\mathtt{M})$	$\mathfrak{A}_\Sigma(\mathtt{AJCC\_TNM\_7\_Stage})(x_\mathtt{T}, x_\mathtt{N}, x_\mathtt{M}) = \dots$		
	`SIGN_TNM_Stage` : $\mathtt{T} \times \mathtt{N} \times \mathtt{M} \longrightarrow \mathtt{Stage}$	$\mathtt{SIGN\_TNM\_Stage}(x_\mathtt{T}, x_\mathtt{N}, x_\mathtt{M})$	$\mathfrak{A}_\Sigma(\mathtt{SIGN\_TNM\_Stage})(x_\mathtt{T}, x_\mathtt{N}, x_\mathtt{M}) = \dots (\neq \mathfrak{A}_\Sigma(\mathtt{AJCC\_TNM\_7\_Stage})(x_\mathtt{T}, x_\mathtt{N}, x_\mathtt{M}))$		
		type constructors			
	$\mathsf{S}_\Sigma = (\{\mathtt{type}\}, \mathtt{Q})$	$\mathsf{T}_{\mathsf{S}_\Sigma} Y$	$\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{type}) = \mathtt{Set}$		
	`nat` $:\longrightarrow$ `type`	`nat`	$\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{nat}) = \mathbb{N}$		
	$\mathtt{s}, \mathtt{t} :\longrightarrow \mathtt{type}$				
	$\phi : \mathtt{type} \longrightarrow \mathtt{type}$	$\phi(\mathtt{nat})$	$\mathfrak{A}_{\mathsf{S}_\Sigma}(\phi(\mathtt{nat})) = \mathfrak{A}_{\mathsf{S}_\Sigma}(\phi)(\mathbb{N}) = \phi(\mathbb{N})$		
	$\Rightarrow : \mathtt{type} \times \mathtt{type} \longrightarrow \mathtt{type}$	$\mathtt{s} \Rightarrow \mathtt{t}$	$\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{s} \Rightarrow \mathtt{t}) = \mathrm{Hom}(\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{s}), \mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{t}))$		
		combinatory			
	$\Sigma' = (S', \Omega')$				
	$S' = \mathsf{T}_{\mathsf{S}_\Sigma}\emptyset$				
	$\lambda_0^0 :\longrightarrow \mathtt{nat}$	λ_0^0	$\mathfrak{A}_{\Sigma'}(\lambda_0^0) = \mathfrak{A}_\Sigma(0)$		
	$\lambda_1^{\mathtt{succ}} :\longrightarrow (\mathtt{nat} \Rightarrow \mathtt{nat})$	$\lambda_1^{\mathtt{succ}}$	$\mathfrak{A}_{\Sigma'}(\lambda_1^{\mathtt{succ}}) \in \mathrm{Hom}(\mathfrak{A}_{\Sigma'}(\mathtt{nat}), \mathfrak{A}_{\Sigma'}(\mathtt{nat}))$		
	$\mathtt{app}_{\mathtt{s},\mathtt{t}} : (\mathtt{s} \Rightarrow \mathtt{t}) \times \mathtt{s} \longrightarrow \mathtt{t}$	$\mathtt{app}_{\mathtt{nat},\mathtt{nat}}(\mathtt{succ}_1^\lambda, 0_0^\lambda)$	$\mathfrak{A}_{\Sigma'}(\mathtt{app}_{\mathtt{nat},\mathtt{nat}}(\mathtt{succ}_1^\lambda, 0_0^\lambda)) = \mathfrak{A}_\Sigma(\mathtt{succ}(0))$		

3.2 Ontology logic specification: Government

SIGNATURE		VOCABULARY AND MEANING		STATEMENTS AND REASONING	
Sorts	**Operators**	**Terms**	**Algebras**	**Sentences**	**Logical consequence and satisfaction relations**
basic logic with given sorts and without type constructors					
$\Sigma = (S, \Omega)$		$\mathsf{T}_\Sigma\{X_\mathtt{s}\}_{\mathtt{s}\in S}$	$\mathfrak{A}_\Sigma$	$\mathsf{Sen} = \ldots$	$\vdash_\Sigma \models_\Sigma$
`t`	ω		$\mathfrak{A}_\Sigma(\mathtt{t}), \mathfrak{A}_\Sigma(\omega)$		
`observable_entity`		$x_{Breslow\_depth\_staging\_for\_melanoma} :: \mathtt{observable\_entity}$	$\mathfrak{A}_\Sigma(\mathtt{observable\_entity}) = ?$		
`finding`		$x_{Clark\_melanoma\_level...} :: \mathtt{finding}$			
`procedure`	$\mathtt{Excision\_of\_melanoma} :\rightarrow \mathtt{procedure}$	$x_{Excision\_of\_melanoma} :: \mathtt{procedure}$			
type constructors					
	$\mathsf{S}_\Sigma = (\{\mathtt{SNOMEDtype}\}, \mathtt{Q})$	$\mathsf{T}_{\mathsf{S}_\Sigma} Y$	$\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{SNOMEDtype}) = ?$		
	$\mathtt{observable\_entity} :\rightarrow \mathtt{SNOMEDtype}$	`nat`	$\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{nat}) = \mathbb{N}$		
combinatory					

Firstly note, that 'SNOMED' (or 'SNOMED CT') as such is not a sort on the topmost level, i.e., is not a sort in S. However, we can (but don't have to) see SNOMED as being a type `SNOMEDtype` under the S_Σ signature, but it is far from clear what $\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{SNOMEDtype})$ would be. There may be a number of intuitions about it, but it is important that there is a reasonable degree of consensus about that particular semantics. It can't be the 'universe of everything intuitively residing within SNOMED', or something similar. Already here we have an an example of "what SNOMED isn't".

Note also how $\mathfrak{A}_\Sigma(\mathtt{observable\_entity})$ clearly is a subset of the overall SNOMED list of 'observable entities', so $\mathfrak{A}_\Sigma(\mathtt{observable\_entity})$ would be some structured subobject of $\mathfrak{A}_{\mathsf{S}_\Sigma}(\mathtt{SNOMEDtype})$. However, SNOMED does not provide any discussions on such semantics, nor does description logics, or some its particular logics like EL++, come to rescue in these respects. We are thereby expanding the list of "what SNOMED isn't".

The remarks above are rather foundational, and are more easily by-passed in pragmatic approaches. The question e.g. about 'Excision of melanoma', and it being a constant $\mathtt{Excision\_of\_melanoma} :\rightarrow \mathtt{procedure}$ in some implementation, and a variable $x_{Excision\_of\_melanoma}$ (in form of a term of a certain type, i.e., $x_{Excision\_of\_melanoma} :: \mathtt{procedure}$) in some other implementations, is, however, more severe. This really comes down to the essence of knowledge representation, and this is why SNOMED's logical binding to descriptions logic is much more of a restriction than an opportunity.

4 "What SNOMED is and what SNOMED isn't"

A rather equivalent formulation of the title of this section is "What Description Logic is and what Description Logic isn't". As a logic, Description Logic is very poor. It is basically a 'propositionalization' of a predicativist's view on logic. It thereby destroys types, which is severe, and in fact there are no real operator based underlying signatures in Description Logics.

Description logic is very much unable to typing, and reasoning in general for that matter, and it is not entirely wrong to be concerned about the health and medical standards community accepting that 'ontology' in 'health and medical ontology' is logically the same as 'ontology' in 'web ontology'. Using the 'house' concept in 'garden house' to build a 'summer house' is not all that advisable.

5 Melanoma in Medical Record and Quality Register

Melanoma in Medical Record is not entirely SNOMED based, but is nevertheless drained with secondary care and professional society oriented terminologies.

Melanoma in Quality Register could, and perhaps should, be more SNOMED based

6 Some examples

Given the increase in the incidence of skin cancer

- What is the effect of national or regional GPwSI training on increase of early stage skin cancer detections?
- What is the effect of national or regional GPwSI training on decrease of late stage skin cancer detections?

What is the cost difference

"early/late stage" defined by SNOMED? "early/late stage" defined by clinicians logic?

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The "NEOPLASMS - ***Melanoma*** (C43-C44) Ontology" is on-going work as is in this 31 January 2012 version not intended for distribution. It is used in discussions with potential cooperation partners.