Clinical Documents and Their Parts

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Abstract. The medical world is replete with documents that ontologies can help to analyze and disambiguate. This paper provides a mereological analysis of such documents as structured by informational slots and fillers, completing recent work by our teams inspired by Bennett. It introduces the notion of adequate filling of an informational slot, and the representation of the layered structure of a document. An application is provided on the Prescription of drugs ontology (PDRO).

Keywords. Mereology, Document structure, Informational slot, Information content entity, Drug prescription, Granularity

1. Introduction

The medical world is replete with documents that ontologies can help to analyze and disambiguate, enabling better data sharing: diagnosis sheets [1], drug prescriptions [2], drug dispensing reports [3], laboratory test prescription and laboratory test reporting documents [4], consent forms [5], questionnaires and surveys [6], etc. Important information is typically extracted from such clinical documents, such as the drugs that a patient is likely to take, or the medical conditions he is likely to have. Nevertheless, the semantics of the extracted information is often derived from implicit knowledge about the structure of the document itself. This can lead to potentially serious errors of interpretation. Therefore, an ontological analysis of clinical documents can produce fruitful, practical and significant results in terms of quality of care. For example, it is important to be able to distinguish the information 'diabetes' when it plays the role of a therapeutic indication in a drug prescription from the information 'diabetes' when it describes a past medical condition of a patient: intuitively, both have something in common (the content 'diabetes'), and something different (two different clinical roles played by this content). Additionally, it would be desirable to be able to represent unfilled templates of documents, or partially filled document.

Ontological foundations for documents have been proposed [7][8] based on the Basic Formal Ontology (BFO) [9] and the Information Artifact Ontology (IAO) [10]. Recent work has axiomatized the mereological structure of informational entities [11], reconsidering classical mereological systems that are traditionally used in formal ontology. This paper will build upon this work by introducing additional important notions, and showing how those can be used to analyze the mereological structure of

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clinical documents. Those new notions include the distinction between the adequate and inadequate filling of documents or parts or documents; and the stratification of document parts in hierarchized sublevels, that enables to express some axioms on how specific kinds of clinical documents should be filled and understood. Those notions will be first introduced on a toy example of a past medical history document, and later applied to the ontology of drug prescriptions PDRO.

2. The Mereological Structure of Informational Entities

2.1. Former Work

The axiomatic system will be expressed in FOL, and translated in OWL 2 when possible, using the OWL Manchester Syntax. Classes from the Open Biomedical Ontologies (OBO) Foundry [12] will be maximally re-used, such as IAO:*Information content entity* (the prefix indicates the ontology from which the term is extracted).

Classical mereology systems rest on the idea that an entity can only have a part once [13]. However, some entities can have a part twice (or more) over, such as universals (e.g. the universal of methane having the universal of hydrogen as part four times [14] [15]). Informational entity particulars share this characteristic with universals: consider the chain of characters 'aa' that has the same letter 'a' twice over, or the sentence 'A cat is a cat.' that has the same word 'cat' twice over. To account for this, we proposed [11] an axiomatization of the mereological structure of documents adapted from Bennett's work [14].

This system introduces the unary predicate IS = "is a slot" and IF = "is a filler", that will be transposed here in OWL as the classes *Information slot* and *Information filler*. In a way that is compliant with IAO [10], fillers and slots are both information content entities, which are defined and brought into existence by some cognitive acts (usually coordinated inside a group whose members share a semiotic system [11] [16]; see also section 6.2).

It also introduces the binary predicate F, S and P, where Sty means that t is a slot of y (where both fillers and slots can have slots), Fxt means that x fills t, and Pxy means that x is a part of y. Those will be written in OWL respectively as the relations **fills** (inverse: **filled_by**), **slot_of** (inverse: **has_slot**) and **part_of** (inverse: **has_part**).

As explained in [11], this axiomatic system is built on a domain of fillers (with the associate predicate $IFx :=_{def} \exists t\ Fxt$) and slots (with the associate predicate IS), which are disjoint: $IFx \rightarrow \neg ISx$. Only slots are slots of something ($Stx \rightarrow ISt$), but some slots may not be a slot of anything (on the other hand, by definition, every filler fills a slot). Therefore, only slots are filled, and only fillers can fill: $Fxt \rightarrow (ISt \;\&\; IFx)$ (but not all slots need to be filled: there can be "empty" slots, as when a slot structure has already been decided for a document that is not filled yet). Proper parthood is defined as filling a slot of a filler ($PPxy :=_{def} IFy \;\&\; \exists s\ (Sty \;\&\; Fxt)$) and parthood is defined the classical way on this basis ($Pxy :=_{def} IFx \;\&\; [PPxy \lor (x=y)]$). Axioms are introduced to ensure that no entity fills any of its slots ($\neg(Stx \;\&\; Fxt)$), that there is at most one filler for a given slot ($Fyt \;\&\; Fzt \rightarrow y=z$), and that S is a strict order relation.

The following axiom (named "AX8" in [11]) was accepted: if a filler x fills a slot t, any slot of x is a slot of t, and *vice versa*: $Fxt \rightarrow (Sux \leftrightarrow Sut)$. From this, a theorem of slot inheritance could be derived, that states that slots of a part of an entity are slots of that entity too: (Stx & Pxy) → Sty. On this basis, P was proven to be a partial order relation, in line with the classical view of parthood [17] (and P is also taken to satisfy a specific axiom akin to weak supplementation, but involving S).

2.2. Example

Suppose that at Princeton–Plainsboro Teaching Hospital (abbreviated PPTH), all past medical history documents have the same structure as $pmhd_1$=‘$patient_1$[] $condition_1$[]’, where ‘$patient_1$[]’ is a particular slot supposed to be filled with a patient name, and ‘$condition_1$[]’ is a particular slot supposed to be filled with the name of a medical condition (for example a disease, a disorder or a pathological process, following the ontology OGMS [18]) that the patient got in the past (for the sake of simplicity, we omit slots that would realistically need to be present, such as a slot to be filled by the date at which the condition was supposed to hold, or by the name of the doctor who wrote the document; we also suppose that each patient referred in the system has only one past condition).

Consider now that $pmhd_1$ is filled such that it reads ‘John Doe / flu’. Both its structure and content could be described with the following notation: $pmhd_1$=‘$patient_1$[‘John Doe’] $condition_1$[‘flu’]’, equivalent to the following facts:

fills(‘John Doe’, ‘$patient_1$[]’) ; **fills**(‘flu’, ‘$condition_1$[]’)

slot_of(‘$patient_1$[]’, $pmhd_1$) ; **slot_of**(‘$condition_1$[]’, $pmhd_1$)

One can then deduce the following facts from the definition of **part_of**:

part_of(‘John Doe’, $pmhd_1$) ; **part_of**(‘flu’, $pmhd_1$)

To illustrate the above-mentioned axiom AX8 with this example, if ‘John Doe’ fills the slot ‘$patient_1$[]’, and ‘last $name_{JD}$[]’ is a slot of ‘John Doe’ (filled by ‘Doe’), then ‘last $name_{JD}$[]’ is also a slot of ‘$patient_1$[]’.

The apparatus of slots and fillers enables an informational entity to have a part twice over. Suppose for example that past medical history documents at PPTH would have an additional field to be filled with the name of the doctor writing the prescription, such that a particular document would read ‘$patient_1$[‘John Doe’] $condition_1$[‘flu’] $doctor_1$[‘Gregory House’]’. Suppose now that Dr. House diagnoses that he has himself a curmudgeon personality, and fills accordingly $pmhd_2$ = ‘$patient_2$[‘Gregory House’] $condition_2$[‘curmudgeon personality’] $doctor_2$[‘Gregory House’]’ (although such self-diagnosis would not be possible in most real-world medical jurisdictions). Then the same information filler ‘Gregory House’ fills two slots, namely ‘$patient_2$[]’ and ‘$doctor_2$[]’.

3. Adequate and Generalized Filling

3.1. A Taxonomy of Relevant Entities

We will introduce the classes as represented on Figure 1, that will be explained below (see [11] and Section 6.2 below for a discussion of instances of *Information slot* carrying aboutness, and thus this class being a subclass of *Information content entity*). Note that an IAO:*Document* is considered as an *Information filler*, and thus fills a slot. Indeed, this class is defined as “A collection of information content entities intended to be understood together as a whole”, and the slot it fills is precisely what makes that this collection of information content entities is to be understood as a whole (see [11] for more discussion on this point).

Given what we said earlier, we can already constrain the slot structure of a *PPTH past medical history document* as follows:

PPTH past medical history document SubClassOf *Document*
and **has_slot** exactly 1 *Patient slot* and **has_slot** exactly 1 *Condition slot*

We will now move to characterize slots depending on whether they are adequately filled or not.

- *IAO:Information content entity*
  - *Information filler (IF)*
    - *IAO:Document*
      - *PPTH past medical history document*
    - *Human name*
      - *PPTH patient name*
    - *Clinical condition name*
  - *Information slot (IS)*
    - *Adequately filled slot*
    - *Patient slot*
      - *Adequately filled patient slot*
    - *Condition slot*
      - *Adequately filled condition slot*

Figure 1. A taxonomy of relevant classes

3.2. Adequate and Generalized Filling

The notion of filling needs to be refined. As a matter of fact, there are three different ways in which a document can be inadequately filled. Suppose that the past medical history documents at PPTH hospital have the structure presented on Figure 2 (namely the structure described earlier, with the additional constraint that the slot for the patient name has two slots, one for the first name and one for the last name).

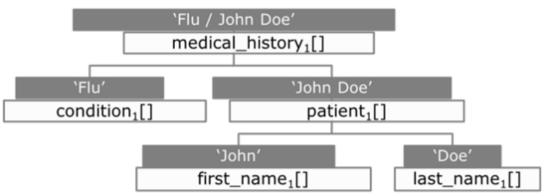

Figure 2. A past medical history document at PPTH hospital

First, suppose that Dr. House leaves the slot last_name$_1$[] unfilled by simply filling medical_history$_1$[] with 'John / Flu'. This is what we will call "structural inadequacy": a slot of the document is not filled. Second, suppose that Dr. House fills condition$_1$[] with a filler that is not of the expected kind, such as 'Gregory House' (see section 6.2 for a more general discussion of what we mean here by "expected kind"). Here, 'Gregory House' is a name of a human person, whereas we would expect condition$_1$[] to be filled with a name of medical condition. This is what we call "semantic inadequacy". Third, Dr. House might fill the document as pictured on Figure 1, but still commit a mistake, if, in fact, John Doe never had the flu in the past. This is what we call "descriptive inadequacy".

The notion F we introduced earlier should be understood as a notion of "adequate filling" in the structural and semantic senses mentioned above (for a short discussion whether it should include descriptively adequate filling, see section 6.2). However, it can be completed by a relation F^G of generalized filling, used when a filler fills a slot, whether adequately or not (such that in particular, $Fxt \rightarrow F^Gxt$). On this basis, we can introduce the notion of generalized information filler (IF^G) as something that *generally* fills a slot (rather than *adequately* fills it): $IF^Gx :=_{def} \exists t\ F^Gxt$. Trivially, an adequate filler is a generalized filler: $IFx \rightarrow IF^Gx$. We can then define a new notion of generalized proper parthood (PP^G) as generally filling a slot ($PP^Gxy :=_{def} IF^Gy \ \& \ \exists t\ (Sty \ \& \ F^Gxt)$)), and define generalized parthood (P^G) between generalized fillers as being a generalized proper part or identical ($P^Gxy :=_{def} IF^Gx \ \& \ [PP^Gxy \lor (x=y)]$).

We can adapt the axioms previously exposed for F to F^G and state that no entity *generally* fills any of its slots ($\neg(Stx \ \& \ F^Gxt)$) and that there is at most one *general* filler for a given slot ($(F^Gyt \ \& \ F^Gzt) \rightarrow y=z$). However, we do not transpose the axiom AX8 for general fillers: a general filler and the slot it fills *do not* necessarily have identical slot structures (for example, 'Gregory House' and '$condition_1[]$' do not have the same slot structure when the former structurally *in*adequately fills the later; Section 5.2 will explain why this would be problematic). We accept axioms stating that P^G is anti-symmetric and transitive (and it is trivially reflexive), and thus is a partial order (we will not discuss here whether P^G should satisfy supplementation axioms similar to those satisfied by P).

Our ontology admits empty slots: if the community at PPTH has decided that all past medical history documents should have one patient slot and one condition slot, then empty past medical history documents already have *ipso facto* this structure, even before they are filled [11]. Therefore, not all slots need to be generally filled (and obviously, also not adequately filled).

Axiomatically, we cannot state that a patient slot can *only* be generally filled by a human name, since as we saw above, an agent might by mistake fill a patient slot with, say, a condition name. However, we can state that a patient slot can only be *adequately filled* by a human name. More generally, we could introduce axioms constraining what could be adequate fillers for each kind of slot:

Patient slot SubClassOf **filled_by** only *PPTH patient name*
Condition slot SubClassOf **filled_by** only *Clinical condition name*

We can then introduce the class of *Adequately filled slot*:

Adequately filled slot EquivalentTo
Information slot and (**filled_by** some *Information filler*)

Note that an adequately filled slot is not the "composition" (in whatever sense of this term) of a slot with its adequate filling; it is a slot that is adequately filled. We have:

Adequately filled patient slot EquivalentTo
Patient slot and (**filled_by** some *PPTH patient name*)

Adequately filled condition slot EquivalentTo
Condition slot and (**filled_by** some *Clinical condition name*)

A reasoner would deduce from those two axioms that *Adequately filled patient slot* and *Adequately filled condition slot* are both subclasses of *Adequately filled slot*.

4. Direct Slots and Direct Parts

4.1. Definitions

To clarify the slot structure of a document, we can define a hierarchy of levels among slots. Consider a past medical history document as represented on Figure 1. Note that by slot-transitivity, 'first_name$_I$[]' and 'last_name$_I$[]' are slots of 'medical_history$_I$[]'. But we might want to state that the slots 'patient$_I$[]' and 'condition$_I$[]' are *direct slots* of 'medical_history$_I$[]', whereas the slots 'first_name$_I$[]' and 'last_name$_I$[]' are not (they are direct slots of 'patient$_I$[]', however).

Let's write the relation "direct slot of" S^D in FOL and **direct_slot_of** in OWL. Then we can say that a direct slot of x (where x can be either a slot or a filler) is a slot of x that is not a slot of a slot of x:

(DEF1) **Direct slot of** $S^D tx :=_{def} Stx \ \& \ \neg[\exists u \ (Stu \ \& \ Sux)]$

We will call the inverse relation "has direct slot" and write it "**has_direct_slot**" in OWL.

We can then define the relation "direct proper part of" P^D ("**direct_proper_part_of**" in OWL) as adequately[3] filling a direct slot:

(DEF2) **Direct proper part of** $PP^D xy :=_{def} \exists t \ (S^D ty \ \& \ Fxt)$

We will call the inverse relation "has direct proper part" and write it "**has_direct_proper_part**" in OWL.

Thanks to this notion, we can write, for example, that a PPTH past medical history document has one *Patient slot* and one *Condition slot* as direct slots; and that it only has such direct slots:

PPTH past medical history document EquivalentTo *Past medical history document*
and **has_direct_slot** exactly 1 *Patient slot*
and **has_direct_slot** exactly 1 *Condition slot*
and **has_direct_slot** only (*Patient slot* OR *Condition slot*)

However, a filled *PPTH past medical history document* can have other slots, as long as they are not direct slots – such as the slot 'last_name$_{JD}$[]' inherited from the filler 'John Doe' that fills its patient slot.

4.2. Axiomatization of Direct Slot and Direct Parthood

Let us now propose an axiomatization of the new relations we introduced, namely S^D (**direct_slot_of**) and PP^D (**direct_proper_part_of**). Note that many of those axioms are not (fully) representable in OWL (see [19] for a discussion), so we will write them in FOL.

4.2.1. Axiomatization of Direct Slot

Since S is irreflexive and asymmetric (and S^D implies S), S^D also trivially is:

(THE1) **Direct-slot irreflexivity** $\neg S^D tt$

(THE2) **Direct-slot asymmetry** $S^D ut \rightarrow \neg S^D tu$

However, although S is transitive, S^D is anti-transitive:

[3] Note that we might have additionally defined *generalized* direct parthood as *generally* filling a direct slot, but such a notion will be less useful for our applied purposes that will be exposed in section 5.2.

(THE3) **Direct-slot anti-transitivity** $S^Dxy \,\&\, S^Dyz \rightarrow \neg S^Dxz$

Proof: Suppose that S^Dxy & S^Dyz. Then, we do have Sxy & Syz. If S^Dxz, then for every u, ¬(Sxu & Suz): contradiction by taking u=y. Therefore, we have $\neg S^Dxz$.

From AX8 that states that the slots of an adequate filler are identical to the slots of the filled slot, we can prove that the *direct* slots of a filler are identical to the *direct* slots of the adequately filled slots (that is, a slot and its adequate filler have the same direct slot structure):

(THE4) **Direct slots of an adequate filler are identical to direct slots of the filled slot**
$Fxt \rightarrow (S^Dux \leftrightarrow S^Dut)$

Proof: Suppose that Fxt. S^Dux iff Sux & ¬[∃v, (Suv & Svx)] by definition of S^Dux.
iff Sut & ¬[∃v, (Suv & Svt)] by AX8.
iff S^Dut by definition of S^Dut.

We have shown in [11] that a slot of a part of an entity is a slot of this entity. However, this slot cannot be a direct slot of this entity:

(THE5) **Inherited slot of part is not direct** $(Stx \,\&\, Pxy) \rightarrow \neg S^Dty$

Proof: Suppose that Stx & Pxy. Since Pxy, there is a slot u such that Fxu and Suy.
By AX8 and Stx, we have Stu. Stu & Suy contradicts S^Dty, therefore $\neg S^Dty$.

4.2.2. Axiomatization of Direct Parthood

Note first that since S^D is a subrelation of S, direct parthood trivially implies proper parthood:

(THE6) **Direct proper parthood implies proper parthood** $PP^Dxy \rightarrow PPxy$

As we have seen, PP is irreflexive, asymmetric and transitive. Therefore, from THE6, we deduce that PP^D (**direct_proper_part_of**) is also irreflexive and asymmetric:

(THE7) **Direct proper parthood irreflexivity** $\neg PP^Dxx$

(THE8) **Direct proper parthood asymmetry** $PP^Dxy \rightarrow \neg PP^Dyx$

PP^D is not transitive, as a direct part of a direct part of z may not be a direct part of z: consider $a=t_1[x]\ t_2[u_1[y]\ u_2[z]]$ (where x, y and z are atomic), where z is not a direct part of a, but is a direct part of $u_1[y]\ u_2[z]$, which is a direct part of a. However, PP^D is also not anti-transitive, as a direct part of a direct part of b might be a direct part b: consider $b=t_1[x]\ t_2[u_1[x]\ u_2[y]]$, where x is both a direct part of b and a direct part of a direct part of b – namely, $u_1[x]\ u_2[y]$.

In addition to its usefulness for writing universal restrictions, such a non-transitive relation might be useful to mitigate undecidability issues when cardinality restrictions are used [20].

5. Application to Drug Prescriptions

Let us now illustrate how those notions can be useful on an actual ontology, the Prescriptions of Drug Ontology (PDRO) [2]. PDRO is a candidate ontology to the OBO Foundry [12], built in compliance with the realist methodology. It specifies generally the structure of drug prescriptions through some relevant classes constrained by some axioms. We will describe here how PDRO could be enriched by using the notions of slots, adequate filling and direct slots and parts.

5.1. Using Slots to Structure Drug Prescriptions

Consider an example of prescription written by Dr. House to John Doe, similar to the one presented in [2], but structured using slots as in Figure 3: 'Amoxicilin 500 mg PO q8h x 7 days'.

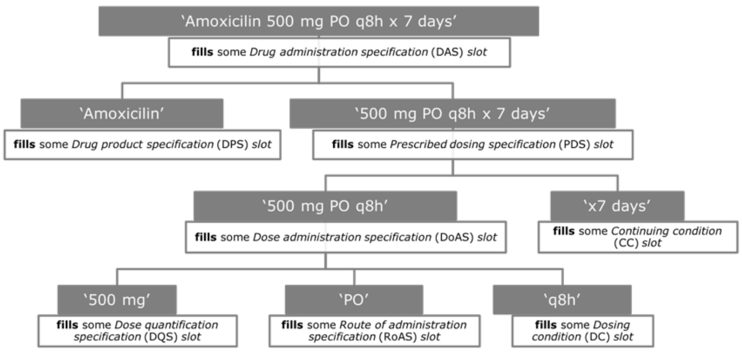

Figure 3. The layered filled slot structure of a drug prescription.

5.2. Using Universal Quantifier with Direct Slot and Direct Part

In practice, drug prescriptions are further constrained according to the areas (e.g. countries) in which they are written. In particular, in order to direct the implementation of e-prescribing in Quebec using an application ontology, we need to constrain what kind of parts a drug prescription can have.

We want to formalize that a drug product specification in Quebec (that we will call here a *Q-Drug product specification*) can be composed only with instances of *Drug active ingredient specification*, *Drug excipient specification, Drug dose form specification*, *Drug product brand name*, or *Drug Identification Number*. However, we cannot use the relation BFO:**has_part** to express this universal restriction; just as a *Drug product specification* like 'Apo-Metoprolol 50mg tablet' has as part a *Drug product brand name* like 'Apo-Metoprolol', it has as part e.g. 'mg'. Thus, it is difficult, if not impossible, to make a list of all the possible parts of a *Q-Drug product specification*.

To address this representational issue, we can introduce relevant slots, and use the relation **has_direct_slot** to state:

(AX_QS) *Q-Drug product specification slot* SubClassOf **has_direct_slot** only
(*Drug active ingredient specification slot* or *Drug dose form specification slot*
or *Drug product brand name slot* or *Drug excipient specification slot*
or *Drug Identification Number slot*)

This explains why we refused to adapt the axiom AX8 for generalized filling; otherwise, an instance of *Q-Drug product specification slot* that would be inadequately filled by, say, ‘John Doe’, would have the same slots as its filler, namely one for the first name and one for the last name, and therefore axioms such as AX_QS would not hold.

Combining this with the notion of adequate filling we saw earlier, we can then list all the (adequate) direct parts an instance of *Q-Drug product specification* can only have:

Q-drug product specification SubClassOf **has_direct_proper_part** only (*Drug active ingredient specification* or *Drug dose form specification* or *Drug product brand name* or *Drug excipient specification* or *Drug Identification Number*)

Those can be combined with axioms using existential quantification, for example stating that an adequately filled drug product specification in Quebec has as part an active ingredient specification or a drug product brand name, in order to specify the drug:

Adequately filled Q-drug product specification SubClassOf **has_direct_proper_part** some (*Drug active ingredient specification* or *Drug product brand name*)

6. Discussion

A number of issues pertaining to the mereological structure of informational entities have been discussed elsewhere [11] (including the possible relaxation of the axiom AX8, the diachronic identity of informational entities, and the introduction of mereological sums). We will add here a couple of points.

6.1. Direct Parthood and Granularity

We introduced above the **has_direct_slot** and **has_direct_proper_part** relations to stratify the relation of parthood (between informational fillers) into several levels. This is a way to address the vexed problem of how to represent consistently granular levels of reality, in the particular case of informational entities (see e.g. Vogt’s [21] BFO-inspired domain granularity framework for the life sciences). Note however that levels between informational entities can be determined by a community of users of a semiotic system [16], since such levels are defined by cognitive acts that can be coordinated in a community, as explained earlier; whereas those between material objects (e.g. between collections of cells and organisms) presumably are not defined by such cognitive acts.

6.2. Aboutness, Semantic Adequacy and Descriptive Adequacy

We can now suggest a few considerations on aboutness for slots and fillers, although this question deserves more attention in future works. Note that cognitive acts are considered in IAO as providing intentionality to information content entities [10]. Since cognitive acts also bring information slots into existence, as mentioned earlier, it is not surprising that they can also provide intentionality to those, the same way they do for information fillers. In IAO [10], ICEs can be about individuals or classes: ‘John Doe’, for example, is about the human person John Doe; and ‘Flu’ would be about the *Flu* class. Similarly, information slots can be about a class. ‘patient$_0$[]’, for example, would be about the class of patients from the PPTH hospital. This explains why we classified *Information slot* as a subclass of *ICE*.

This theory of aboutness need to be developed more systematically to express formally the normative constraints on adequate filling that were mentioned above. In particular, the semantic adequacy requirement for a filler was expressed as being about an entity of the "expected kind". We can clarify what we mean by this with two paradigmatic cases. A first case is that 'John Doe' is a semantically adequate filler of $patient_0$[] because 'John Doe' is about a particular (the human person John Doe) who is an instance of the class referred to (we take "refer to" and "being about" as synonymous here) by $patient_0$[], namely the class of patients from the PPTH hospital. A second case is that 'Flu' is a semantically adequate filler of $condition_0$[] because it is about a class (the class of flu diseases) that has a non-empty intersection with the class referred to by $condition_0$[] (namely the class of human medical conditions; note that the former is not a subclass of the latter: the class of flu diseases encompasses also non-human medical condition, as some non-human animals can get the flu). A more systematic theory of semantic adequacy will depend on the details of the endorsed theory of aboutness.

A theory of aboutness could also clarify the link between descriptive adequacy and semantic adequacy. A filler is said to be descriptively adequate if it describes a state of affairs that obtained in the past; for example, 'John Doe / Flu' is descriptively adequate if it refers to a state of affair of John Doe having got the flu in the past. But descriptive adequacy might be seen as a form of semantic adequacy. For example, the slot $past\_history_0$[] might be about the class of clinical state of affairs that occurred in the past; and 'John Doe / Flu' is a descriptively adequate filler if it refers to a state of affair (John Doe having had the flu) that is an instance of the class of clinical state of affairs that obtained in the past (assuming that we would accept an ontology of state of affairs, which is not the case currently in BFO). Thus, this would match with our definition of semantic adequacy. Here again, interpreting descriptive adequacy as a kind of semantic adequacy depends on the details of the theory of aboutness accepted. Moreover, even if descriptive adequacy can be interpreted as a kind of semantic adequacy, it is epistemically much more demanding to evaluate some descriptive adequacy than to evaluate, say, the semantic adequacy of a filler of $condition_0$[]. Indeed, it is relatively easy to check whether a filler refers to a human condition (by having a dictionary or terminology of human conditions); on the other hand, it is much more difficult (or even impossible, if one is a strict Bayesian) to be sure that John Doe indeed got the flu in the past.

7. Conclusion

We have here shown how the mereology of informational entities proposed in [11] could be extended with a normative notion of adequate filling, and a hierarchical notion of direct slots and parts. Both are useful tools to represent clinical documents and their parts, and could also be used to represent documents in non-clinical domains. Systematic theories of aboutness of information fillers and information slots need to be developed in the future to represent axiomatically the notion of adequate filling. The deontic import of some slot (e.g., a signature slot) should also be investigated in the future. The articulation of this ontological system with relational databases could be investigated. As a matter of fact, a mapping might be made between an attribute in a relational database and a class of slots (e.g., an attribute describing therapeutic indications might correspond to a class of slots that each refer to the class of therapeutic indications); whereas identical values in a relational database's fields might correspond to the same filler (e.g. all values of ‘diabetes’ could be retrieved, independently of whether they describe a therapeutic indication or a past medical condition). Finally, similarities with the type theory in computer science might provide some insight for this articulation with computer systems.

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