Description Logic Based Icons Semantics: An Ontology for Icons

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***Abstract*—Iconic communication is paramount today in order to assist people with disability (e.g. illiteracy) enjoying, as much as everybody else, the advances in information and communication technologies (e.g. Internet). Previous works tend to generalize iconic communication by translating iconic sentences into XML documents. Theses approaches are limited owing to the fact that an icon can hide several metaphors. In fact, the semantics of an icon is not the linguistic equivalent associated to the image, but is a set of attributes which can be used to describe the given icon. Second, an XML schema is not a knowledge representation, but just a message format. Therefore, to manage the knowledge hidden behind iconic sentences, a semantic model for icons needs to be formally defined. This paper extends previous icon models by first, introducing a description logics-based definition of icons semantics, and second, based on those formal definitions and the Web Ontology Language (OWL) , we create an Ontology for Icons named IcOnto (read *"eye can too"*). We further use IcOnto to model some properties of the African Traditional Medicine (ATM), for illustration.**

Keywords: Iconic Systems, OWL Ontology, Description Logics, African Traditional Medicine.

I. Introduction

Iconic communication is the base of the most arts and rituals, which by their major power of evocation achieve to make communication between people when the natural language is unusable. Iconic systems have different definitions depending on the person who is conceiving it. For some group of people, an iconic system can be defined as a system which uses icons to exchange information with or between its users; it is for example iconic systems developed for technologic assistance. For another group of people, an iconic system is seen as a system which manipulates iconic objects. This paper is classified in the case of technologic assistance. In other words, our objective at the level of application, is to establish communication through Internet between African Traditional Medicine (ATM) practitioner who are usually illiterate and therefore cannot communicate through interfaces built in natural languages such as English, Spanish or French. Moreover, ATM practitioner usually transmit their knowledge orally from father to son, from mother to daughter, from mouth to ear; therefore some information might be lost. To approach such a problem, we aim to provide to ATM practitioner a way to store, manage and exchange their knowledge using new technologies of communication. Using iconic communication seems adequate for the ATM practitioner needs.

Many types of iconic systems have already been developed in the case of technologic assistance. These iconic systems are generally integrated into graphic interfaces and make up for communication deficit. For example Minspeak System [1] uses an iconic keyboard which the combined selection of keys permits the construction of sentences semantically extensive. We can also talk of Edith system [2], which is a system conceived to help patients to communicate with their environment; IBS system [3] which offer possibilities to doctor in medicine to query a relational data base although they don't know how to write SQL queries; VilAug system [4] is used to help foreigners to communicate in a country where they do not know the natural language; SCILX [5] which permits to ATM practitioners to store informations about making potions in a multimedia data base on ATM [8], this by translating iconic sentences into XML documents. In short, these systems translate iconic sentences into natural language, they also translate iconic queries into SQL queries and finally they translate iconic sentences into XML documents. Moreover, most of the iconic systems are developed independently of the existing iconic system, that is, when building an iconic system, an author cannot reuse the previously constructed iconic system or at least suit the existing systems to his needs. Besides, using XML technologies can appear as a step forward to the generalization of iconic communication. But, using XML seems not enough. In fact, the semantic of an icon is not the linguistic equivalent associated to the image, but it is a set of metaphors which can be used to describe the given icon. Secondly, an XML document is not a knowledge representation, but a message format. In other words, XML provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents. It could then be more interesting to formalize iconic communication by introducing a formal semantics of icons which can first be used in each domain to inferred properties of the given domain, second which can be reused or updated each time a new author is using it, and finally which can enabled iconic communication through Internet. Building an OWL (Web Ontology Language) [10] ontology seems indicated.

Therefore, in this paper, we extend our previous models by

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first, introducing a description logics-based definition of icons semantics, and second, based on those formal definitions and the Web Ontology Language (OWL) , we create an Ontology for Icons named IcOnto (read *"eye can too"*). We further used IcOnto to model some properties of African Traditional Medicine (ATM), for illustration.

The rest of the paper is organized as follow: Section 2 briefly presents our previous work on this field; Section 3 introduces a description logics based semantic of icons; Section 4 describes IcOnto, an Ontology for Icons; we present in Section 5 how we used IcOnto to model and inferred some properties of ATM; and Section 6 concludes the paper and introduces some future works.

II. Background

Our previous work [5] on iconic system introduces SCILX, a XML-based iconic communication system which enables communication through the Internet using the World Wide Web and the XML technologies. The approach has a formal foundation based on formal grammars of icons. It allows to translate an iconic sentence into a XML document and reversely. The components of SCILX is depicted in Fig.1(a).

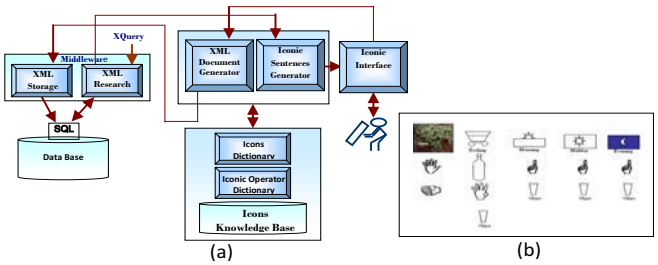

Fig. 1. (a) SCILX Architecture, (b) Example of Iconic Sentence

The user enters iconic sentences through the iconic interface. Those iconic sentences are transmitted to the XML document generator which translates the iconic sentences into a tree. The Icons knowledge base is used to replace iconic information into lexical information and the tree is then used to do the semantic interpretation of the iconic sentences by using the inference engine contained in the icons knowledge base. Then, the XML document is constructed and stored in the middleware XML.

Let us now give an example of construction of a potion to treat stomachache with the medicinal plant "centella" (Take five handfuls of centella and boil it with four glasses of water then drink one glass of the decoction in the morning, one glass midday and one glass in the evening). The iconic sentence associated to this potion is showed in Fig.1(b).

There is nothing which could assure the system that, the image displays as Centella is at least a plant icon. Besides, there is not a possible way for the system to deduce for example the set of icons representing a plant, a number or a quantity. It would be interesting if we can internally represent a plant as an icon of green color which quality are usually ingredients and are generally located on the ground. That is why new solutions for semantics representations of icons are needed.

III. Formal Semantics of an Icon

A. Concepts of an Icon

Icon Algebra[7] defined an icon X as a pair (X_m, X_i) where X_m represents the meaning of the icon, or the logical part, and X_i represents the image, or the physical part. But, first of all, the interpretation of an icon depends on the user who is interpreted it; therefore his interpretation will depend on his cultural and linguistic background. Secondly, the semantic of an icon is not only the linguistic or cultural equivalent associated to the image, but also, it is a set of metaphors which can be used to describe the given icon. Thus, an icon can hide several metaphors or concepts. Based on the diagram, types of semantic relationship presented in [6], we extract a list of possible concepts of an icon. These concepts are divided specially into two types: direct representation and association. Direct representation includes the following concept:

1) *Color* : The color of the icon, this might have the values: red, blue, green...;
2) *Shape*: Shape of the icon, this might have the values: squared, triangle, circular, pyramid...;
3) *Transparent*: This might have the word attribute:
   a) *Is_a_concrete* : representing the concrete meaning of the icon
   b) *Is_an_abstract*: representing the abstract meaning of the icon

Association includes the following concepts:

1) *Quality*: The quality hidden by the icon
2) *Quantity*: This might have the following word attributes
   a) *Mass_quantity*: weight hidden by the icon
   b) *Count_quantity*: number hidden by the icon
3) *Location*: to denote if the icon is representing a location or where the icon is usually displayed or found.
4) *Activity*: to denote what the icon is used for.
5) *Emotion*: to denote what does the icon make us feel
6) *Time*: might have the attribute sequence; which is used to express time sequencing, for example, winter, summer, morning, evening, or a time slot.
7) *Convention*: This might have the word attributes:
   a) *Linguistic*: for linguistic interpretation of the icon
   b) *Cultural*: for cultural interpretation of the icon
8) *Sound*: This might have the attributes: *Rhyme*, *Rebus*, *Syllable_Identity*, *Homophony*, *Alphabetic_abr*.

Fig.2 (a) and (b) show examples of two icons with their corresponding concepts interpretations.

We now associate concepts between each other to create roles and we obtain the icons semantics presented in the following subsection.

B. Description logic-based icon semantic

Description logic describes domain in terms of concepts (classes), roles (properties, relationships) and individuals.

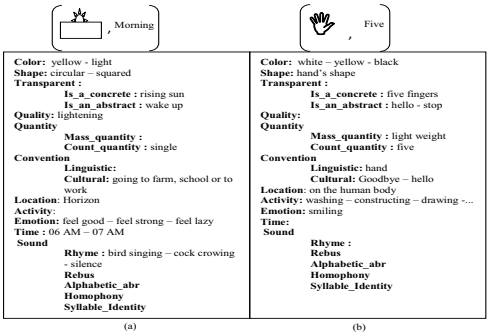

Fig. 2. Example of two icons with their concepts interpretation

We wrote our icons semantics following the roles supported by the description logics family language $\mathcal{SHOIN}^{(\mathcal{D})}$ [9]. $\mathcal{SHOIN}$ is the basis for World Wide Web Consortium's (W3C) Web Ontology Language (OWL) [10].

We create three main concepts Icon, Icon_PhysicalPart and Icon_LogicalPart. Icon is the atomic concept, it subsumes Icon_PhysicalPart and Icon_LogicalPart. Icon_PhysicalPart subsumes all the concepts representing the physical part of an icon, that is the image of the icon; while Icon_LogicalPart subsumes all the concepts representing the logical part of the icon, i.e the concepts deduced from the meaning of the icon. Fig.3 shows the description logics based semantics of iconic concepts.

There are no mandatory naming conventions for OWL classes. So, in this paper, all class names (or concepts names) start with an uppercase letter and should not contain spaces; an uppercase letter is used to join two word and underscores are used to join words of two different classes , for example *Icon_PhysicalPart*. All properties names(or roles names) start with a lowercase letter, should not contain spaces; an uppercase letter is used to join two words, for example *hasColor*. All individuals start with an uppercase letter, for example *Green*. Literally from Fig.3, an icon has a physical part, that is, the image representation of the icon. The concepts which can be directly deduced from the image representation of an icon are its shape and its color. The concept color is an enumerated concept, it can be green, red, yellow, ... Or, it can be a combination of two or more colors from the enumeration list. The shape, as the concept color, is an enumerated concepts, it can have the value circle, square,...Or, it can be a combination of two or more values from the enumeration list. An Icon has a meaning (logical part): it is the literal and or cultural interpretation of the image representation of the icon; and also some associated meaning which can be hidden behind the icon. In other words, a logical part of an icon has at least one transparent; that is the concrete and abstract interpretation of the icon. There also might exists behind the logical interpretation of the icon, a cultural or linguistic convention, a location, a quality, a time, an activity, an emotion, a quantity or a sound.

Icon = Icon_PhysicalPart ∧ Icon_LogicalPart
Icon_PhysicalPart = ∃ ≥ 1 hasColor.Icon_PhysicalPart_Color
∃ ≥ 1 hasShape.Icon_PhysicalPart_Shape
Icon_LogicalPart = ∃ ≥ 1 has Transparent.Icon_LogicalPart_Transparent∨
∃hasConvention. Icon_LogicalPart_Convention ∨
∃hasLocation. Icon_LogicalPart_Location ∨
∃hasQuality. Icon_LogicalPart_Quality ∨
∃hasActivity. Icon_LogicalPart_Activity ∨
∃hasEmotion. Icon_LogicalPart_Emotion ∨
∃hasQuantity. Icon_LogicalPart_Quantity∨
∃hasSound. Icon_LogicalPart_Sound ∨
∃hasTime. Icon_LogicalPart_Time
Icon_LogicalPart_Transparent = Icon_LogicalPart_Transparent_Abstract ∨
Icon_LogicalPart_Transparent_Concrete
Icon_LogicalPart_ Convention= Icon_ LogicalPart _ Convention _Linguistic ∨
Icon_ LogicalPart _ Convention _Cultural
Icon_LogicalPart_ Quantity= Icon_ LogicalPart _ Quantity _MassQuantity ∨
Icon_ LogicalPart _ Quantity _CountQuantity
Icon_LogicalPart_ Sound= Icon_ LogicalPart _ Sound _Rhyme ∨
Icon_ LogicalPart _ Sound _Rebus∨
Icon_ LogicalPart _ Sound _SyllableIdentity∨
Icon_ LogicalPart _ Sound _Homophony∨
Icon_ LogicalPart _ Sound _AlphabeticAbbreviation
Icon_LogicalPart_ Time= Icon_ LogicalPart _ Time _SequenceOfTime
Icon_PhysicalPart_Color = {Green, Red, Yellow, Blue, Pink, White…}
Icon_PhysicalPart_Shape = {Circle, Squared, Oval…}
Icon_LogicalPart_Transparent_Abstract = String*
Icon_LogicalPart_Transparent_Concrete = String*
Icon_ LogicalPart _ Convention _Linguistic = String*
Icon_ LogicalPart _ Convention _Cultural = String*
Icon_ LogicalPart _ Quantity _MassQuantity = Number
Icon_ LogicalPart _ Quantity _CountQuantity = Number
Icon_ LogicalPart _ Sound _SyllableIdentity = String*
Icon_ LogicalPart _ Sound _Homophony = String *
Icon_ LogicalPart _ Sound _AlphabeticAbbreviation = String *
Icon_ LogicalPart _ Time _SequenceOfTime = {winter...}| Hour "-" Hour
String = (SpecialCharacter | Letter)*
SpecialCharacter = Digit | "-"|"_"
Letter = UppercaseLetter | LowerCaseLetter
UppercaseLetter = [A..Z]
LowercaseLetter= [a…z]
Number= Digit+
Digit = [0…9]
Hour = Hr":"MinSec":"MinSec
Hr = {0…23}
MinSec = {0…59}

Fig. 3. Semantic of Icons

IV. Icon Semantics in use: Building an Ontology for Icon (IcOnto)

To create our ontology, we used Protege-OWL [11], which supports $\mathcal{SHOIN}^{(\mathcal{D})}$. An OWL ontology consists of Individuals, Properties, and Classes, which roughly correspond to Protege frames Instances, Slots and Classes. Individuals also known as domain of discourse represent objects in the domain in which we are interested. For example, individuals for the concepts Icon_PhysicalPart_Color could be Green, Red, Yellow... The concepts in our icon semantics become classes and roles become properties. The rules for building the ontology are the same as those defined by the Protege-OWL Consortium.

For example, the class *Icon_PhysicalPart* = ∃ ≥ *1hasColor.Icon_PhysicalPart_Color* ⋀ ∃ ≥ *1hasShape.Icon_PhysicalPart_Shape* is interpreted in Protege by assigning the super class *(hasColor* ***some*** *Icon_PhysicalPart_Color)* ***and*** *(hasShape some Icon_PhysicalPart_Shape)* to the class *Icon_PhysicalPart*. Its corresponding part in the owl file generated is presented in the XML file below:

$< SubClassOf >$
$< IRI = "Icon\_PhysicalPart" >$
$< ObjectIntersectionOf >$
$< ObjectSomeValuesFrom >$

$< ObjectPropertyIRI = "hasColor" / >$
$< ClassIRI = "Icon\_PhysicalPart\_Color" / >$
$< /ObjectSomeValuesFrom >$
$< ObjectSomeValuesFrom >$
$< ObjectPropertyIRI = "hasShape" / >$
$< ClassIRI = "Icon\_PhysicalPart\_Shape" / >$
$< /ObjectSomeValuesFrom >$
$< /ObjectIntersectionOf >$
$< /SubClassOf >$

Fig.4 shows print screen of IcOnto class hierarchy in Protege-OWL Graphic User Interface's window.

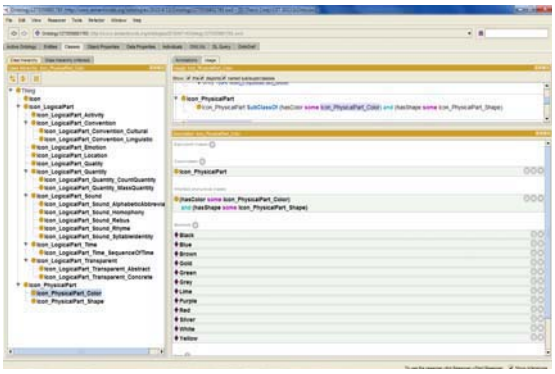

Fig. 4. IcOnto Class Hierarchy in Protege

V. IcOnto in Use: Modeling ATM

In this section, we present how IcOnto can be used to model African Traditional Medicine (ATM). In fact, we used IcOnto to create a knowledge base of icons for ATM. A knowledge base construct with a description logic contains typically two parts: a TBox (Term Box) and a ABox(Assertion Box). Due to page limit, we presents in Fig. 5 a partial TBox constructed to model two elements in ATM, plant and fruit; and in Fig.6 two properties that can be inferred : sweet fruit and medical plant.

PLANT= (∃≥1hasColor.Green) ∧ (∃hasShape.Plant-shape) ∧
(∃hasActivity.Constituents-of-Potion) ∧ (∃hasLocation.Ground) ∧
(∃hasConcrete.Ground-product) ∧ (∃hasAbstract.Feeding-people-and-animal ∨ ∃hasAbstract.Medicine-used) ∧ (¬∃hasSound.sound)
FRUIT = (∃≥1hascolor.Green ∨ ∃≥1hascolor.Red ∨ ∃≥1hascolor.Yellow ∨
∃≥1hascolor.Purple ∨ ∃≥1hascolor.Orange) ∧ (∃hasConcrete.Tree-product) ∧
(∃hasAbstract.Feeding-people-and-animal) ∧ (∃hasShape.Circle ∨
∃hasShape.Oval ∨ ∃hasShape.Arc) ∧ (∃hasLocation.Tree) ∧
(∃hasActivity.Constituents-of-Potion) ∧ (∃hasQuality.Sweet-Taste ∨
∃hasQuality.Acid-Taste) ∧ (∃hasTime.Season) ∧ (¬∃hasSound.sound)

Fig. 5. IcOnto Partial TBox for Plant and Fruit in ATM

MEDICAL PLANT= (∃≥1hasColor.Green) ∧ (∃hasShape.Plant-shape) ∧
(∃hasActivity.Constituents-of-Potion) ∧ (∃hasLocation.Ground) ∧
(∃hasConcrete.Ground-product) ∧ (∃hasAbstract.Medicine-used) ∧
(¬∃hasSound.sound)
SWEET FRUIT = (∃≥1hascolor.Green ∨ ∃≥1hascolor.Red ∨ ∃≥1hascolor.Yellow ∨
∃≥1hascolor.Purple ∨ ∃≥1hascolor.Orange) ∧ (∃hasConcrete.Tree-product) ∧
(∃hasAbstract.Feeding-people-and-animal) ∧ (∃hasShape.Circle ∨
∃hasShape.Oval ∨ ∃hasShape.Arc) ∧ (∃hasLocation.Tree) ∧
(∃hasActivity.Constituents-of-Potion) ∧ (∃hasQuality.Sweet-Taste) ∧
(∃hasTime.Season) ∧ (¬∃hasSound.sound)

Fig. 6. Plant and Fruit properties inferred for ATM

VI. Conclusion and Future Works

We present in this paper an Ontology for Icons called IcOnto. It is the extension of our previous works on iconic systems where we tend to generalize iconic communication by translating iconic sentences into XML documents and reversely. But XML seems to be not enough to manage the knowledge hidden behind icons. We therefore, introduce a description logics-based definition of semantics hidden behind an icon and we used this definition to create an ontology for icons called IcOnto (read *"eye can too"*). We show how IcOnto can be used to describe some concept in African Traditional Medicine (ATM) field and we introduce some inferred properties. For the future works, we are aiming to also define semantics of icon operators. That is, the possible operator which can be used to combine icons together with the aim to construct iconic sentences. Therefore, their possible interpretations can be automatically generated.

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