Ontology-based Database Design for an Injury Research Platform

Mohammad Qodrati, MD[1], Amin Nayebi, PhD[1], Michał Markiewicz, PhD[2], David Lattanzi, PhD[1], Katherine Scafide, RN, PhD[1], Janusz Wojtusiak, PhD[1]

[1]George Mason University, Fairfax, VA; [2]Jagiellonian University, Kraków, Poland

Introduction

Injury research necessitates precise, interoperable data for impactful analysis and patient care. Biomedical ontologies, by standardizing terminology and data structure, play a crucial role in enhancing data sharing and usability across research and clinical settings, thereby improving research outcomes and patient interventions. The presented ontology-based database design is part of a larger project aiming at creating a platform to allow for research and practice supporting analysis of injuries for victims of violence. The platform provides online and mobile access to stored images of injuries as well as structured data that describe the injuries. This poster describes design of an ontology that is used to encode all data in the database. Each injury data may be coded using different variables (characteristics of patient, injury, image, etc.) that are not known ahead of time. To achieve flexibility for accommodating such data, this work uses a hybrid relational/key-value approach for storing data instead of traditional approaches.

Methods

A panel of informaticians and clinicians created hierarchies of the ontology by finding a design that allows for flexibility and is consistent with clinical practice, as well as a method for expanding them as new data arrive. Professional SQL programmers standardized the format for storing the ontology keys/concept IDs, including the major decision of using a hybrid semi-relational design, to ensure high efficiency in concurrent querying and modifying data.

Four main principles in designing the ontology have been used: (1) the ability to incorporate existing data from a previous study[1] as well as new data that are currently being collected in the project or will be attained in the future; (2) linkage to SNOMED CT concepts and incorporating the HL-7 FHIR resources, tailoring them at the same time to fit existing data and use case, as well as linkage to ICD, LOINC, and other standardized terminologies as needed; (3) the ability to model temporal data that describes multiple measurements of injuries and images taken with the ambient white light and alternate light sources over time; (4) avoiding re-inventing taxonomies, by assigning/mapping, for example, SNOMED CT "body structures" to our implemented finding site of an injury.

The ontology is intended to control the behavior of a software platform; thus, it also consists of a considerable number of attributes that have technical and programmatic use. These include "display order" that defines where the data is displayed on the platform's interface, "filter type" that controls menus used to search/filter the data, "data type", etc.

Results

At the time of writing, our ontology mainly consists of 146 concepts, organized around three main hierarchies describing an *injury* (87 concepts) – morphology, color (visible to the naked eyes *versus* readings from reflective spectrophotometer), associated findings (e.g., abrasion, erosion, wound) and features (e.g., pain), approximate age, cause, size, site, and some similar measurements of its surrounding skin for comparison; *subject* (33 concepts) – demographics (e.g., age, gender, race, ethnicity), anthropometric measurements (e.g., weight, height, skinfold thickness, body part circumferences, natural hair and baseline skin colors); and *image* (26 concepts) – size (width and height), resolution, the light source (including visible "white", ultraviolet, alternate monochromatic) and its wavelength (if applicable) under which the photo was taken, special filters used in front of the lens, and an additional ~400 concepts extracted from EXIF metadata of digital images recorded by cameras. The ontology has been incorporated into a working platform with loaded data of about 30,000 injury images.

subj	enc	inj	img	property_key	property_value
1	1			SUBJECT:SKIN_COLOR | COLOR_SYS:FITZPATRICK	COLOR_SYS:FITZPATRICK:I
1	1	1		INJURY:COLOR | RELATIVE:SURROUNDING | COLOR_SYS:CIELAB:CIE-L	70.48
1	1	1	1	IMAGE:AMBIANCE:LIGHT_SOURCE	LIGHT:ALTERNATE:BLUE
1	2	1		INJURY:MEASUREMENT:WIDTH | UNIT:LENGTH:MILLIMETER	13

Conclusions

The ontology is employed as a determining part of a software platform, not a general-purpose biomedical ontology. The latter is achieved by linkage to SNOMED CT, OMOP, ICD, and other standardized terminologies/data models.

References

1. Scafide KN, Sheridan DJ, Downing NR, Hayat MJ. Detection of inflicted bruises by alternate light: Results of a randomized controlled trial. Journal of forensic sciences. 2020 Jul;65(4):1191-8.

2. EAS-ID – Equitable and Accessible Software for Injury Detection [Internet]. [cited 2024 Aug 13]. Available from: https://bruise.gmu.edu/