

Creation of an Ontology for the Assessment of Fundamentals of Medical Ultrasound

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CRESST Conference 2015, Redondo Beach, California
August 19, 2015

National Center for Research
on Evaluation, Standards, & Student Testing

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Outline

- Project goals
- Role of ultrasound evaluation in medicine
- Problem statement
- Solution approach using ontologies
- Results
- Outlook



Project Goals

- Create automated assessment technology for valid, and reliable assessment of ultrasound knowledge and skills
- Integrate conceptual knowledge and simulation-based procedural skills
- Customize technology to align with Military Health System (MHS) requirements
- Use technology as additional component for accreditation evaluation (e.g. ARDMS)



Role of Ultrasound Evaluation in Medicine

- Emergency patient evaluation
- Bed-side ultrasound
- The “new stethoscope, less invasive X-ray, more affordable MRI”
- Fast, affordable, accurate, dynamic (movement is possible – and sometimes required)



The SonoSimulator



- Eric, not sure if you'd like to talk about the simulator

Problem Statement

In the domain of ultrasonography currently none of the following exist:

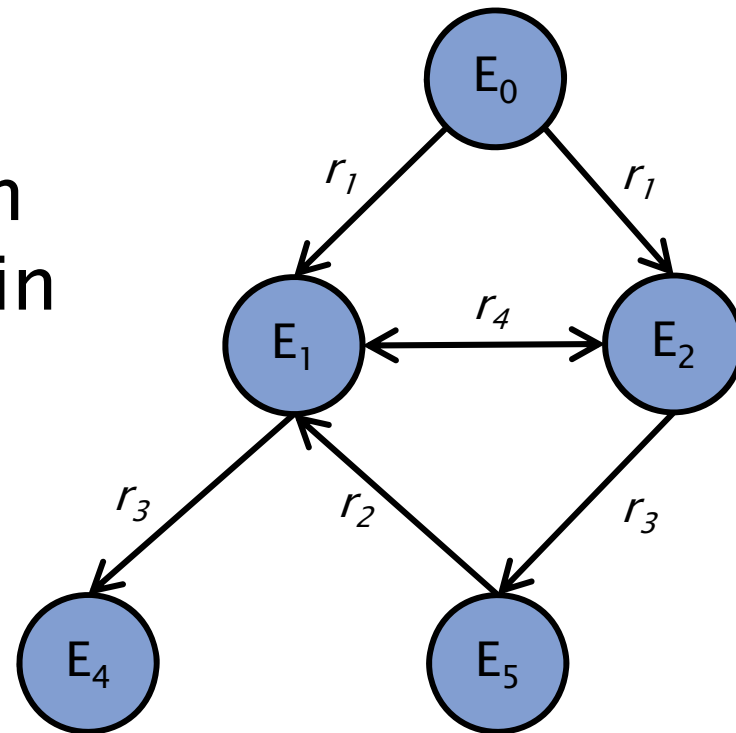
- Technology solutions for integrated automated assessment of conceptual and procedural skills in the domain of ultrasonography
- Learning management systems that integrate instruction and assessment and that recommend next steps
- Student or teacher interfaces that provide feedback on performance



Solution Approach: Ontologies

An ontology is a graphical representation of a domain expressed in terms of entities* and their relations

* concepts, processes, standards, lessons, assessments, cognitive demands, big ideas, people, documents...



E = entities, r = relations



Examples of Ontology Relations

- Taxonomy/Hierarchy: *is-part-of, is-type-of*
- Function: *is-used-to, is-applied-to*
- Property: *is-property-of, is-attribute-of*
- Location in time: *is-taught-before*
- Location in space: *is-above, is-adjacent*
- Dependency: *depends-on, requires, causes*
- Association: *is-associated-with*

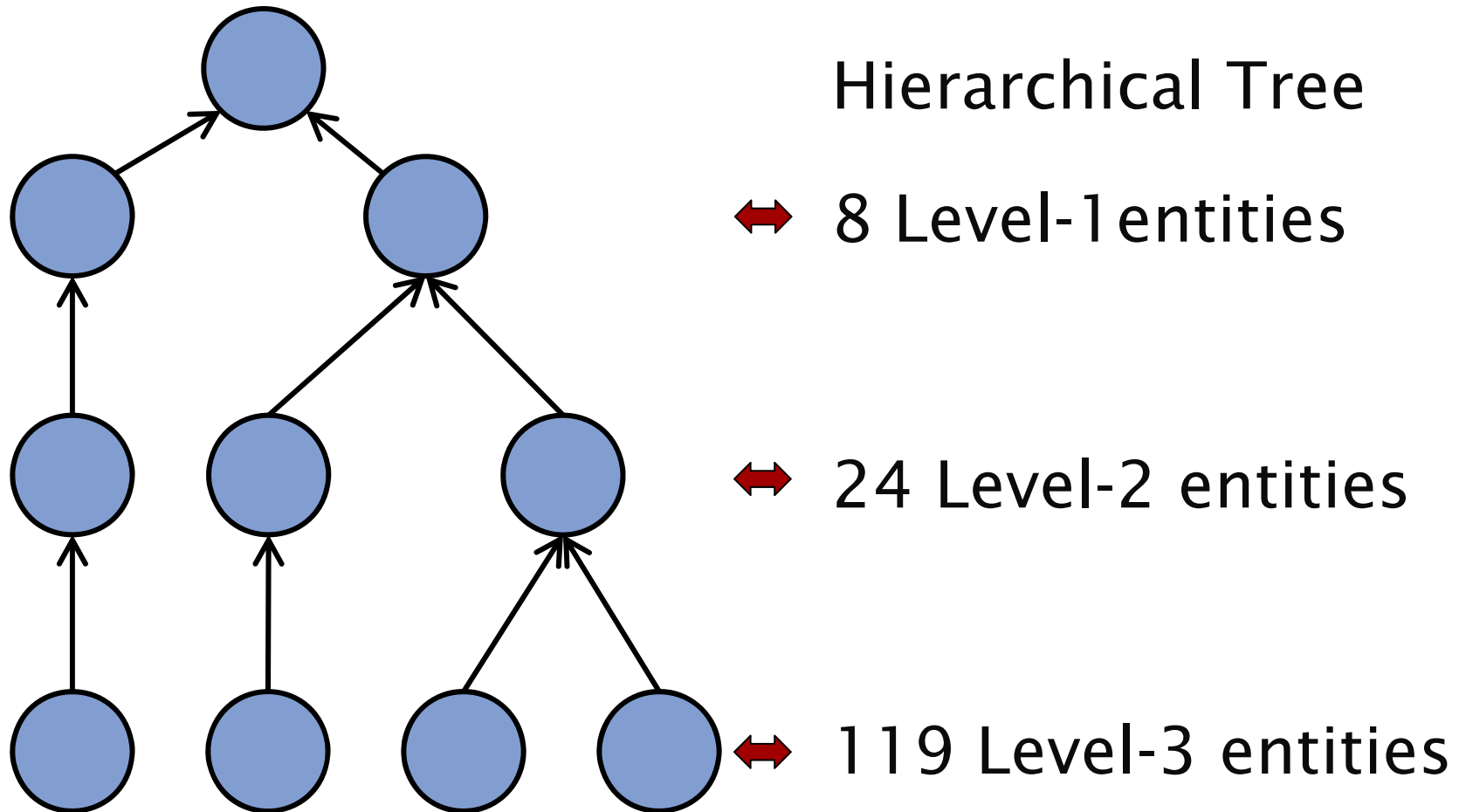


Use of Ontologies

- Visualization
 - ✓ *Graphically display and delineate a domain or subdomain in terms of its entities and their relations*
- Terminology
 - ✓ *Define the meaning of entities*
- Reusability
 - ✓ *Once an ontology is created it can be reused and expanded*
- Modeling
 - ✓ *Transfer dependency relations to computational probabilistic graphical models*



Creation of Fundamentals of Ultrasound KSA ontology

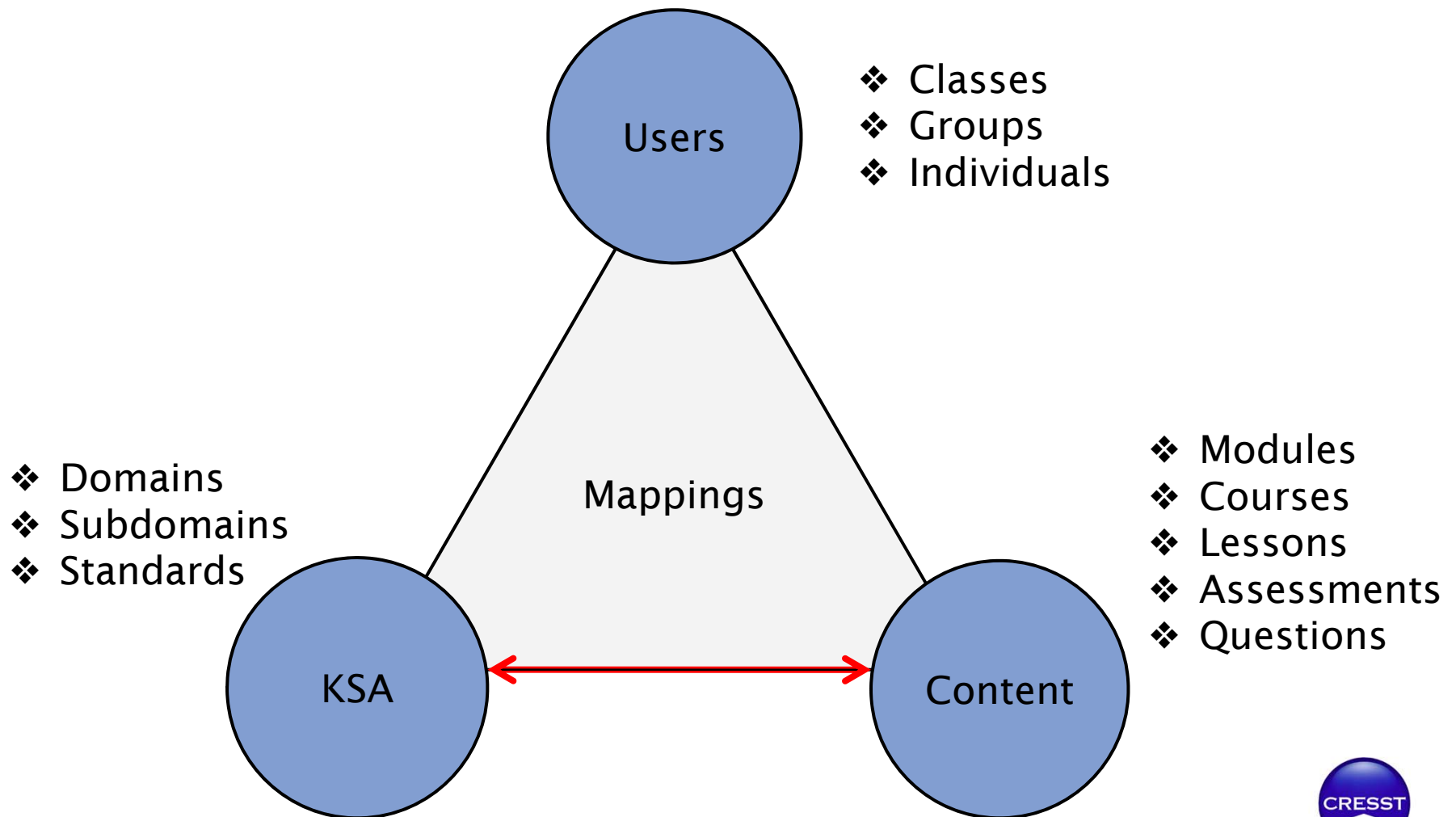


Creation of Fundamentals of Ultrasound KSA ontology

- Top-down approach
 - ✓ *Literature review → 8 Level-1 entities.*
- Bottom-up approach
 - ✓ *Cognitive task analysis of existing content (lessons and quiz questions) → Level-3 entities*
- Connect top and bottom
 - ✓ *“Fill-in the blanks” → Level-2 entities*
- Review, validation, fine-tuning
 - ✓ *Review by 4 domain-experts*
 - ✓ *Feedback from 8 sonographers mapping content to KSA*



Mapping of Ontologies



Rater Mapping of Content to KSA

- Raters
 - ✓ *8 professional sonographers (“mappers”) initially*
 - ✓ *Removed raters with incomplete ratings and with low intra-rater reliability → 4 raters remaining*
- Content entities
 - ✓ *78 entities: 41 quiz questions, 37 lesson slides*
- KSA entities
 - ✓ *89 Level-3 entities addressed*



Results

- The whole process of ontology creation including content-to-KSA mapping took about 6 months
- With rater input we were able to
 - ✓ *Create Q-matrix for each rater*
 - ❖ ***Krippendorff Alpha** of rater agreement (4 raters, 78 units /content items, 89 multi-valued ratings) was 0.55*
 - ✓ *Create (dis)agreement matrices from Q-matrices that helped to*
 - ❖ *Detect problematic KSA definitions*
 - ❖ *Detect missing content*
 - ✓ *Reformulate unclear Level-3 KSA entities*
 - ✓ *Reorganize Level-3 KSA entities and Level-2 KSA entities*
 - ✓ *Update and complete missing content (currently in progress)*



Outlook

- Build a tool to help edit and map ontologies, making the process faster
- Expand the created KSA ontology for fundamentals of ultrasound to include other subdomain of ultrasonography





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Excerpt of Rater Agreement Matrix

Item IDs	KSA IDs											Sum
	8	9	10	11	12	...	102	103	104	105	106	
in1	0	0	0	0	0		0	0	0	0	0	0
in2	1	1	0	0	0		0	0	0	0	0	0
in3	11	2	0	0	1	...	0	0	0	0	0	0
in4q	8	1	0	0	0		0	0	0	0	0	0
tb2	0	1	0	0	1		0	0	0	0	0	0
⋮			⋮						⋮			⋮
t16	0	0	0	0	0		0	0	0	0	0	0
t17	0	0	0	0	0		0	0	0	0	0	0
t18	0	0	0	0	2	...	0	0	0	0	0	0
t19	0	5	0	0	10		0	0	0	0	0	0
t20	11	0	0	0	0		0	0	0	0	0	0
Sum	32	36	0	0	68	...	9	14	7	12	0	1764

