Protégé as Professor:

Development of an Intelligent Tutoring System With Protégé-2000

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Outline

 General requirements for a tutoring system in Pathology

 Practical aspects of Protégé integration into SlideTutor

Further use of Protégé



- Large medical image libraries (VHL)
- Digital knowledge libraries (FMA)
- Knowledge structuring, sharing, utilizing to teach the decision-making process
- Very few good examples in medicine
- Reuse knowledge representation and acquisition in other fields: paradigms, methodology, ideas
- Create system that incorporates empirical knowledge and theories about how people learn
- Build system with reusable components
- Design adaptive, revisable system that can incorporate any new observations



- Systems that use AI formalisms to offer interactive computer-based instruction
- Represent and model knowledge
- Actively monitor and encode student's progress through a problem/case, and/or across problems/cases
- Offer instruction and provide feedback that is adaptive, flexible, individually tailored



- Cognitive Tutor based on ACT-R theory of learning (Anderson, Corbett, and Koedinger)
 - Expert Model problem solving and decision making cognitive domain
 - Declarative "factual" knowledge
 - Procedural knowledge how to do things
 - Proceduralized declarative knowledge in the rules(step instructions)
 - Model Tracing every user action is checked against the Expert Model

Intelligent Tutor System Structure

- Collect data on what student does
- Make predictions on what student knows
- Provide data for pedagogic decision making

Student Module

Expert Model

- Allow correct steps
- Correct errors
- Give hints on next step

Pedagogic Knowledge

- Case sequence
- •When to intervene
- How to intervene
- Canvas for problem solving
- Make goals visible

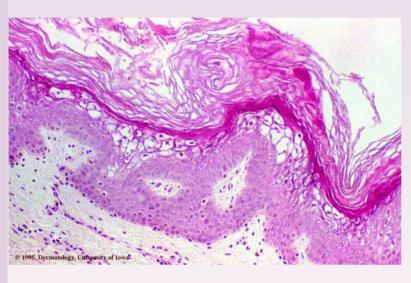
Interface

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- Extremely difficult
- Residents have little time to learn
- False positives and false negatives; errors associated with significant impact to patient
- Some areas are highly algorithmic, seemed straightforward to model with rule system
- Diagnosis more deterministic in Pathology when compared with other domains

Dermopathology Domain

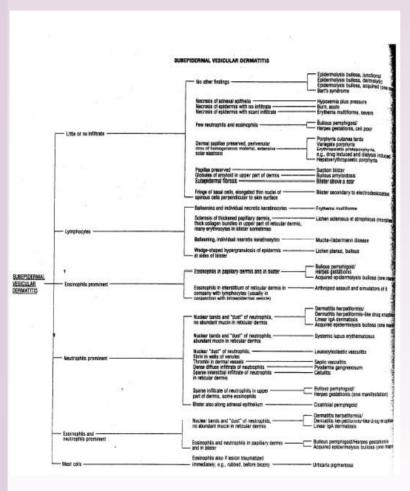


- Visual diagnostic
 - Use of the microscope
 - More precise, visual criteria for reasoning
 - Visual criteria depend on microscope power, can be hierarchically classified



- Visual diagnostic
- Study of expertise in microscopic diagnosis (*Crowley et al., JAMIA 2003*)
 - Identified reasoning steps, goals
 - Physical search, identification, hypothesis testing and refinement
 - Knowledge transformation from novice to expert

Dermopathology Domain

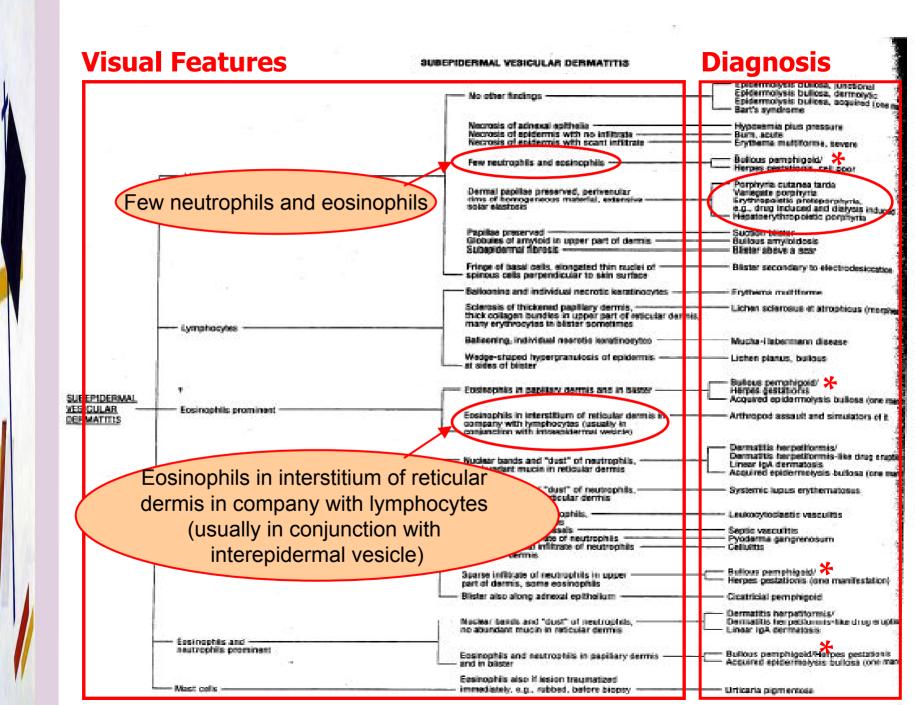


- Visual diagnostic
- Study of expertise in microscopic diagnosis
- Dermopathology domain algorithms

1/11 pattern

Visua	I Features	SUBEPIDERMAL VESICULAR DERMATITIS	Diagnosis
	TĀ.	No other findings	Epidermolysis dulicia, junctional Epidermolysis bulicia, dermolysic Epidermolysis bulicea, acquired jos Bart's syndrome
		Necrosis of adnexal optitudia Necrosis of epidermis with no infiltrate Necrosis of epidermis with scant infiltrate	Hypoxemia plus pressure Burn, acute Erythema multiforme, severe
	and the second second	Few reutrophils and ecsinophils	Bullous pemphigoid/ Hierpes gestationis, cell poor
	Little or no infiltrate	Dermal papillae preserved, perivenular rims of homogeneous material, extensiva — solar elastosis	Porphyria cutanea tarda Vantegate porphyria Erythropoletic protegorohyria, e.g., drug included and distytos indu Hepatoerythop petic porphyria
		Papiliae preserved Globules of arrytoid in upper part of dermis. Subapidermal fibresis	Suction blister Buildous amylfoldosis Blister above a scar
EPIDERMAL GULAR MATTIS		Fringe of basal cells, elongated thin nuclei of ———————————————————————————————————	Blister secondary to electrodesicost
		Ballooning and individual necrotic keratinggytes. —	Frytheris multiforme
	la contra de la contra del la contra del la contra del la contra de la contra del la contra de la contra del l	Scienasis of thickened papillary dermis, thick collagen bundles in upper part of reticular derminance of the collagen bundles in blister sometimes.	Lichen scierosus et atrophicus (me
	Lymphacytes	Balleoning, individual nearetic iteratinosytes	Mucha-Habermann disease
	l.	Wedge-shaped hypergranulosis of epidermis ————————————————————————————————————	Lishen planus, buildus
	,	Ensinophilis in papillary dermits and in buster	Bullous permohigoid/ Herpes destations Acquired epidermolysis bulloss (on
	Eosinophils prominent	Eosinophils in interstitium of reticular dermis in — company with lymphocytes (usually in conjunction with impagideman wester)	Arthropod assault and simulators of
		Wuclear bands and "dust" of neutrophils,	Dermatitis herpetiformis/ Dermatitis herpetiformis-like drug e Linear IgA dermatosis Acquired epidermotysis butlosa (on
	t	Nuclear bands and "dust" of neutrophilis, abundant mucin in reflectar dermis	Systemic lupus erythematosus
	Westrophilis prominent	Nuclear "dust" of neutrophils, fibrin in wells of venues Thrombi in formal vessels	Leukocytoclastic vescultes Septic vascultes
		Dense diffuse infiltrate of neutrophils Sparse intensitial infiltrate of neutrophils in reticular dennis	Pyoderma gangrenosum Celluitts
		Sparse infittrate of neutrophils in upper part of dermis, some eosinophils	Bullous pemphigoid/ Herpes gestationis (one manifestatio
		Blister also along adnexal epitholium	Cicatricial pemphigoid
		Mucher tends and "dust" of neutrophilis, no abundant much in reticular dermis	Dermatitis her petitormis/ Dermatitis her petitormis-tike drug er Linear IpA dermatosis
	eutrophis prominent	Eosinophils and neutrophils in papillary dermis ——and in bilister	Bullous pemphigoid/Herpes gestation Acquired epidermolysis: bulloss (one
	Mast cells	Essimophils also if lesion traumatized immediately, e.g., subbed, before biopsy	Unicaria pipmentosa

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Medical Intelligent Tutoring Systems

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- Individualized instructional system
- Multiple paths for problem solving
- Multi-dimensional decision space
 - Expert, Student, and Pedagogic models

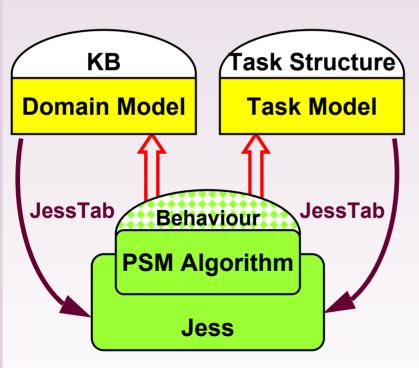
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- Large complex dynamic declarative knowledge
- Formalism of production rule knowledge representation is domain specific (Nx100 rules)
- Maintenance is difficult and time consuming
- Knowledge modification alters the rules



- Use KBS approach to separate static (declarative) and dynamic (procedural) knowledge
- Complicated domain structure exactly fits Protégé knowledge representation paradigm
- In KBS PSMs serve as its reasoning part that can be used by tutor procedural rule based expert system

SlideTutor Approach



- Protégé for declarative knowledge
- Jess Expert System as PSM base
- JessTab bridge (Eriksson, 2003), slightly modified
 - reflect hierarchical Protégé structure
 - work with multiple projects
- Separate abstract graph
 PMS algorithm and specific behaviour

Expert System KB Implementation

- Parametric design approach for classification problem solving (Motta, 1999):
 - find the solution class that best explains certain set of observables for unknown object
 - <u>Solution = Domain KB</u> finite set of feature specifications
 - Observable = Case Representation set of facts
- Extended
 - Redefined Feature to be an object with its own properties
 - Solution { **f** { **a** { **v**}}}
 - Observable (*f*, {*a*, *v*})
 - Added abstract Feature-Attribute-Value ontology

Feature Ontology

- 🕒 :THING 🗛
- 🗣 📵 :SYSTEM-CLASS 🐴
- C FEATURE
 - · 🕒 EPITHELIAL CHANGES (5)
 - C DERMAL CHANGES (7)
 - 🗣 🖸 INFLAMMATION
 - 🕒 NEUTROPHILS (3)
 - ©EOSINOPHILS (2)
 - · 🖸 MAST CELLS (1)
 - · CLYMPHOCYTES (1)
 - · 🖸 VASCULAR (2)
 - **O** VALUE (29)
 - © ATTRIBUTE (4)

© DERMAL CHANGES

Direct Instances



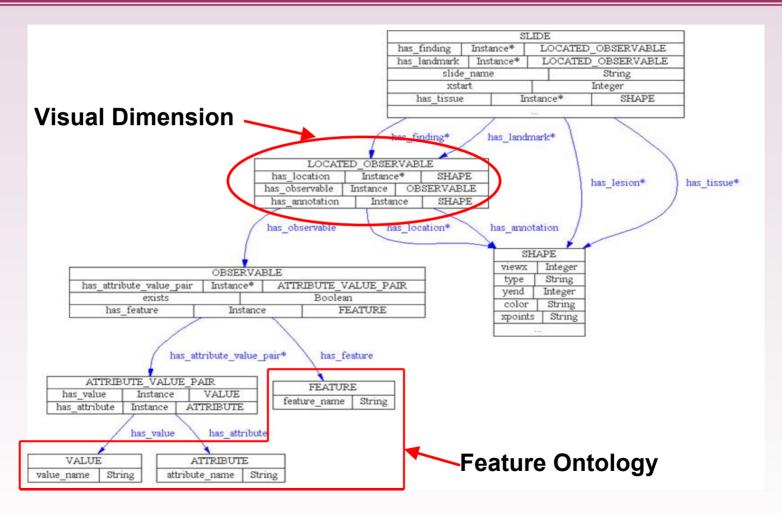
- 🛈 amyloid
- 🛈 fibrosis:
- 🛈 mucini
- point-of-entry vesicle
- 🛈 sclerosis:
- 🗘 solar elastosis
- 🕸 thick collagen bundles:

- Hierarchical
 Feature structure
- Feature –
 Attribute Value independence
- Reused by Domain KB and Case Representation



- Hierarchical diseases representation with allowed multiple inheritance
- DISEASE has FEATURE_SPECIFICATIONs, built up from range of features, attributes and values – multiple disease paths
- FEATURE_SPECIFICATION can have any number of associated DISEASEs – multiple disease set for a particular path
- DISEASE can be extended by tests, UMLS content
- Reusable, not connected to any problem solving environment

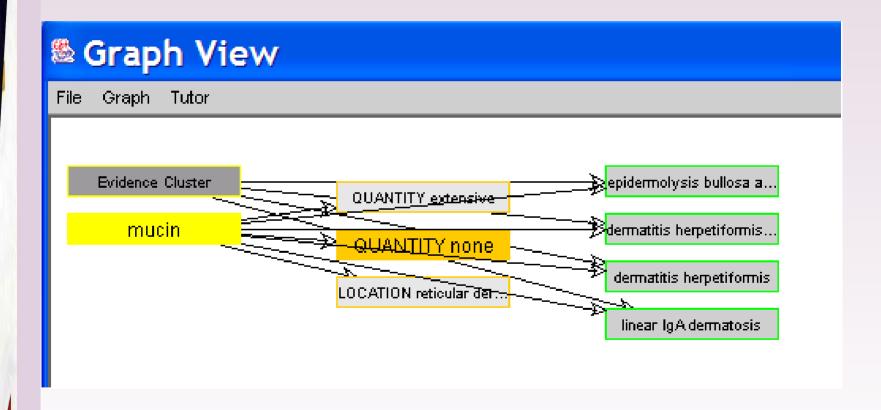
Slide Representation



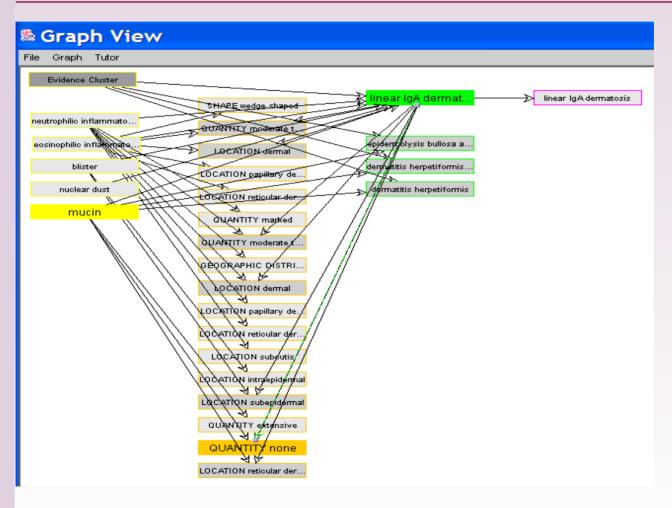
Dynamic Solution Graph (DSG)

- Generates valid path through problem state based on combination of expert model ontologies, case and pedagogic knowledge within abstract PSM
- Dynamic incremental problem state and valid next steps generation system
- DSG state depends on the order of input reasoning events
- Abstract, task-independent, allows any conceptually correct node, makes no decision
- Node type specific response to a triggered event encapsulated in the behavior structures
- DSG visualization (JGraph, www.jgraph.org)

Forward Reasoning and Negation

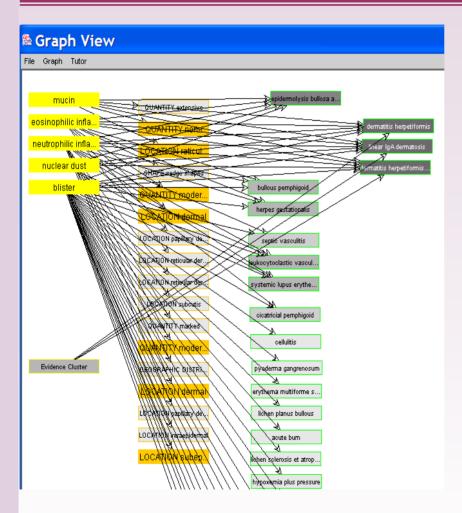


Backwards Reasoning



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Cluster Concept



- Evidence Cluster –
 integrated relation between
 the state of its elements and
 nodes outside the cluster
- Serves as disjunction element that forms the problem solving path
- Allows multiple pedagogic strategies for hypothesis formation:
 - Based on single piece of evidence
 - Consistent with all evidences

Protégé Advantages

- Redefine a knowledge role of shared procedures as a static knowledge
- Knowledge decomposition and inclusion (Feature, Domain and Case ontologies)
- Modularity and extensibility allows independent rules and models development
- Reusable domain for classification problem solving
- Domain neutral for many search identification interpretation reasoning systems
- More Protégé more flexibility



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