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Modifying the model while problem-solving

We model diagnostic problems based on inferring causes by passive observation of a diagnostician's work-flow. Then by recording their findings and final diagnosis, the model can be modified directly, or improved by learning from cases so acquired.



The hidden probabilistic model of the system under diagnosis is necessarily simplified – based on three-layer Bayesian networks with canonical interactions among the network variables – and we are able to reduce greatly the knowledge engineering effort that goes into model building. A single stage, factored diagnostic model, built by user-interaction *during a diagnostic session*

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pressure check	replace vent	pressure check	🗢 🛛 gas smell	sniff in car and
abnormal 9%	abnormal 9%	abnormal 9%	abnormal 100% 📃	abnormal 9%
normal 91%	normal 91%	normal 91%	normal 0% _🖶	normal 91%

- Its is hard for engineers to anticipate all conditions where a model will be used. <u>Model formulation is best</u> <u>done when an actual problem arises</u>, when knowledge about it is cognitively accessible.
- The problem that starts e.g. a diagnostic session, forms a "query."
 - *Query-based inference* means the model is conditioned, all or in part, on the query that initiated the session.
- Query-based Inference can help diagnosis, for example by taking hints for formulating the model from the sequence of actions during a user session.

Learning from just a few cases

Each case specifies the result, as a ranking of faults, f_i by probability, of applying evidence j to the model M. A case is best thought of as a fragment of the correct model, expressing *epistemic* uncertainty rather than stochastic variation in the appearance of faults.

Unlike modifications made by elicitation of causal links, there is no direct way to modify the network by inspection of a set of cases. The *case consistency learning* problem is to determine if the case set is consistent, and if so, to learn, or modify an existing model to be consistent with the set.

Definition: Case Consistency

• There are other advantages to "lazy" model building: smaller models, more focused inference.

A model *M* is consistent with case *j* to level *k* if the list of ordered fault marginals given the evidence $e^{(j)}$ agrees with the case.

 $P(f_1 | e^{(j)} M) \ge \mathbf{L} \ge P(f_k | e^{(j)} M)$

Then the learning problem is to find a model *M*^{*} consistent with all *j* cases.

Two web-based applications

Marilyn is a public website that collects observables, context, and the resulting diagnosis in dialog with the user. It suggests a set of possible diagnoses from among those entered.

Smart Diagnostics is an interactive troubleshooting tool, built in cooperation with our client, by putting a Bayes network behind the workflow-based design they suggested.

Both consist of a web application, the SMILE engine and a

- *Smart Diagnostics* is a test-bed for exploring Query-Based Inference.
- It hides the network structure and probabilities from the user.
- It logs all actions and outcomes of user sessions.
- The user-generated networks form a prior for learning from the collected session logs.

database that persists the model.

Smart Diagnostics	User:amr\jmagost
Bayesian Network Based Troubleshooting	
SELECT TOOL TROUBLESHOOT PROBLEMS RECOMMEND SOLUTIONS	SESSION LOG
1. Select or Create Tool Type	3. Choose or Create Observed Symptoms
MAT Ultima	gas smell pulls to right
Ford Escort GE Washer Vetwork Build Test Vetwork Build Test #2 Vetwork Build Test #3	
2. Select or Create Entity ID Add Remove	4. Continue to Build Model or Perform Equipment Diagnosis
	Start solving an actual problem
	OR
	Start solving a practice problem
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Smart Bayesian Ne	Diagnostics etwork Based Troublesł	User:amr\jmagosta Tool Type: Ford Escort ID:wagon1 Session start:7/23/2008 2:30:		
SELECT TOOL	TROUBLESHOOT PROBLEMS	RECOMMEND SOLUTIONS	SESSION LOG	
	Currei	ntly diagnosing	symptom	: "pulls to right"
ball joint (72% campher (5% disk brake (5% tire tread (2%	6)) %))	Add Edit Remo	ve inspect measure wiggle w Select re	ball joint (1.4) e run out (1.4) /heel test obs:(abnormal) esult: unset normal abnormal
-Or-Enter of inspect ball jo measure run free wheel spi measure cam	or Select a Test to Determin pint (1.4) out (1.4) in (0.6) opher (0.6)	he the Likely Cause	Ve ball joint	Related to Selected Test: : (72%)

Smart Diagnostics ayesian Network Based Troubleshooting				User:amr\jn Tool Type: F ID:wagon1 Session sta	User:amr\jmagosta Tool Type: Ford Escort ID:wagon1 Session start:7/23/2008 2:30:45 P		
ELECT TOOL	TROUBLESHOOT PROBLEMS	RECOMMEND SOLUTIONS	SESSION LOG			He	
Tool Grou	p: Ford Escort	User: amr	\jmagosta				
Entity:	wagon1	Date: Weo	Inesday, July 23, 200	8			
Step	Action	Ent	ry	Comments	Time		
18	Select Remedy	Remove and replace ball jo	pint		2:39:23 PM		
17	Add Remedy	Tighten ball joint housing			2:38:34 PM		
16	Modify Remedy	Remove and replace ball joint			2:38:11 PM		
15	Add Remedy	Remove and replace ball jo	oint		2:37:49 PM		
14	Set Test	wiggle wheel test: abnormal			2:33:49 PM		
13 10	Select Cause Select Test	ball joint visually inspect tread			2:33:24 PM 2:31:42 PM		
9	Select Cause	tire tread			2:31:08 PM		
8	Select Cause	disk brake			2:31:04 PM		
7	Select Cause	campher			2:31:01 PM		
6	Select Cause	ball joint			2:30:55 PM		
5	Select Symptom	pulls to right			2:30:46 PM		
4	Select Tool	wagon1			2:30:46 PM		
3	Select Tool	AMAT503			2:30:46 PM		
2	Select Model	Ford Escort			2:30:46 PM	6	
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