

Design of a diagnosis and follow-up platform for patients with chronic headaches

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Faculty of Engineering and Architecture

Intro

Current process UH Ghent

Platform requirements

Mobile application

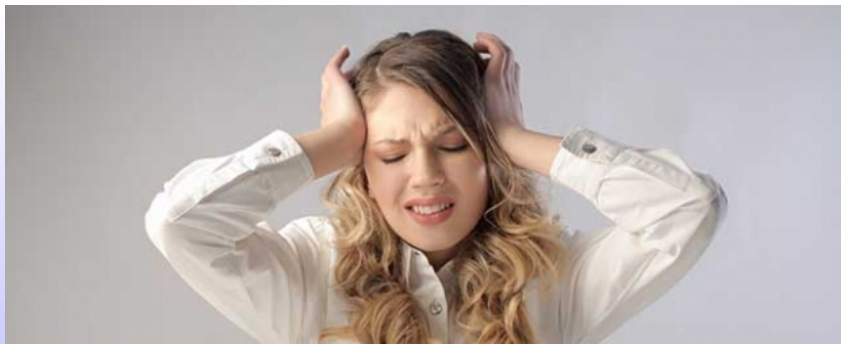
Backend and data exposure

Genetic merging of DT's

Doctor dashboard

Conclusion & future work

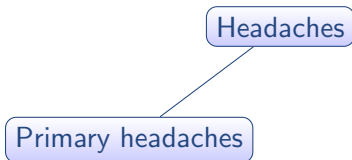
Headaches



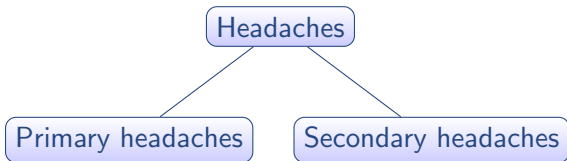
Headaches

Headaches

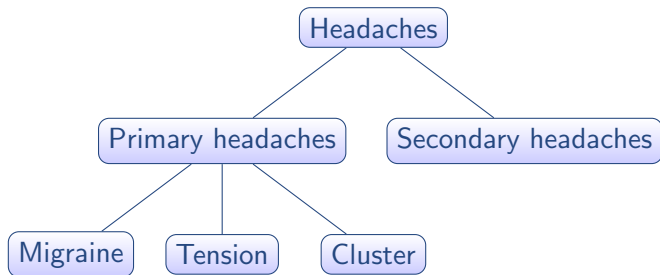
Headaches



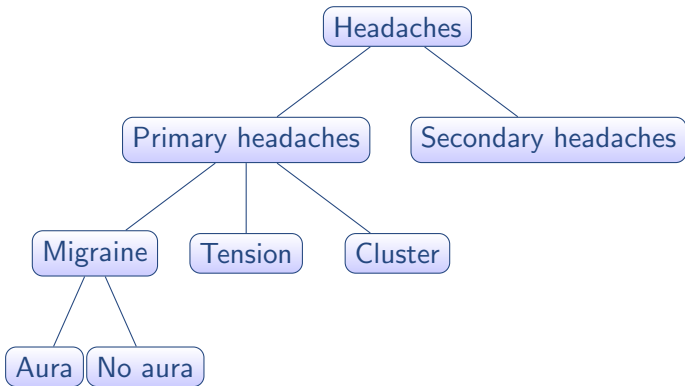
Headaches



Headaches



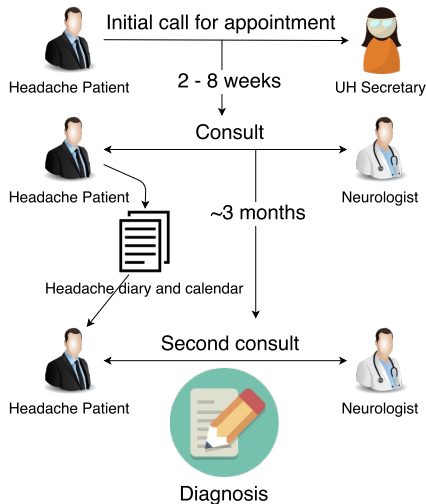
Headaches



Current process UH Ghent

Current process at UH Ghent is:

- ▶ Not digital
- ▶ cumbersome
- ▶ long-lasting



So there is need for a better (digital) alternative! This alternative has to:

- ▶ capture at least the same information as current solution
- ▶ be more efficient
- ▶ provide a second opinion for the doctors (auto-diagnose)

Intro

Genetic merging of DT's

Platform requirements

Doctor dashboard

Mobile application

Conclusion & future work

Backend and data exposure

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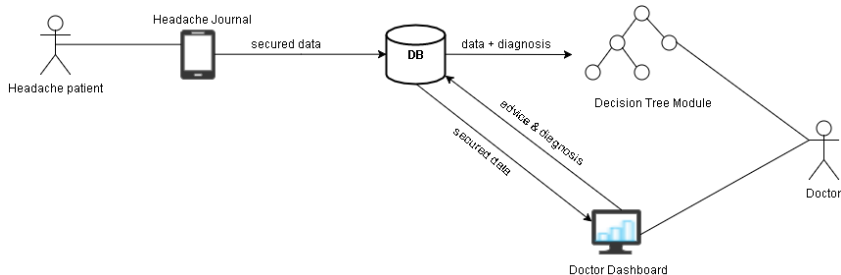
Our proposed alternative consists of:

- ▶ Headache journal: mobile app
- ▶ Doctor Dashboard: web application
- ▶ Machine learning module: decision support

Solution non-functional requirements:

- ▶ Security
- ▶ Availability
- ▶ Performance & learning curve
- ▶ Usability

Platform requirements



Intro

Genetic merging of DT's

Platform requirements

Doctor dashboard

Mobile application
Chronicals

Conclusion & future work

Backend and data exposure

Mobile Application

Why create a new application?

Competition

- ▶ Migraine Buddy
- ▶ Headache Diary
- ▶ Pfizer headache journal

Mobile Application

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All good, but:

Mobile Application

Why create a new application?

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All good, but:

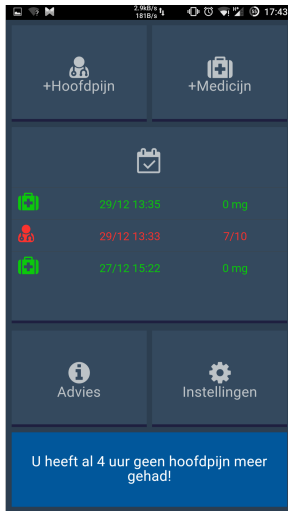
- ▶ none captures all data needed
- ▶ none offers usable data export

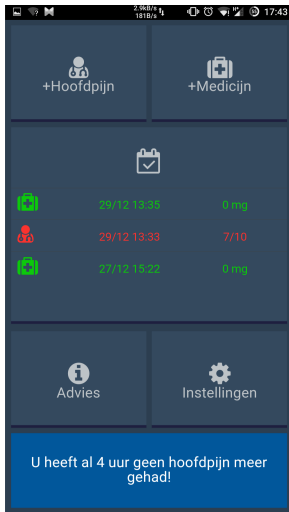
Cross platform vs Native

	Native	Cross-platform
+	+ Native UX	+ 1 language
	+ device-specific features	+ Write once, run everywhere
	+ Better performance	+ Less maintenance
-	- Multiple languages	- Slower (lower performance)
	- Time consuming (development)	- Less device specific features
		- Harder to release online (Play Store/App Store)

Cross platform vs Native

	Native	Cross-platform
+	<ul style="list-style-type: none">+ Native UX+ device-specific features+ Better performance	<ul style="list-style-type: none">+ 1 language+ Write once, run everywhere+ Less maintenance
-	<ul style="list-style-type: none">- Multiple languages- Time consuming (development)	<ul style="list-style-type: none">- Slower (lower performance)- Less device specific features- Harder to release online (Play Store/App Store)

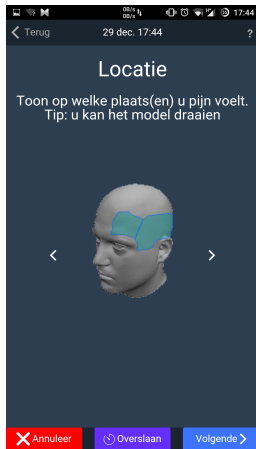




Chronicals



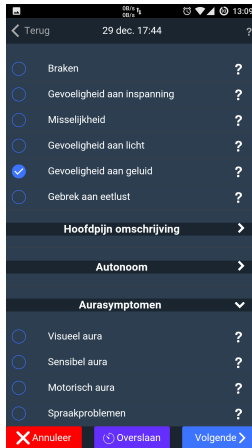
Chronicals



Chronicals

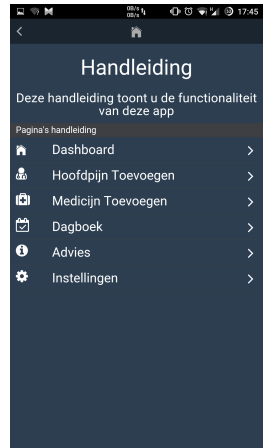
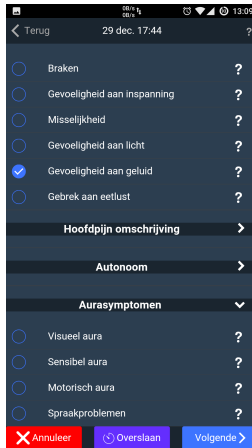


Mobile application



Chronicals

Chronicals



Intro

Genetic merging of DT's

Platform requirements

Doctor dashboard

Mobile application

Conclusion & future work

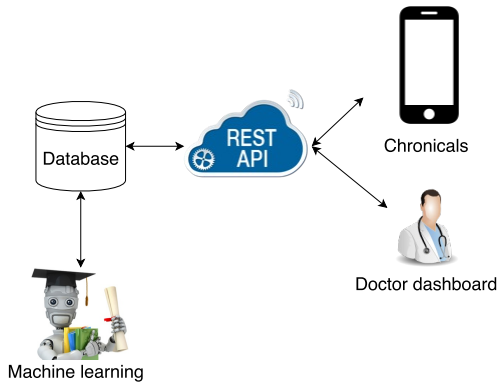
Backend and data exposure

Backend and data exposure

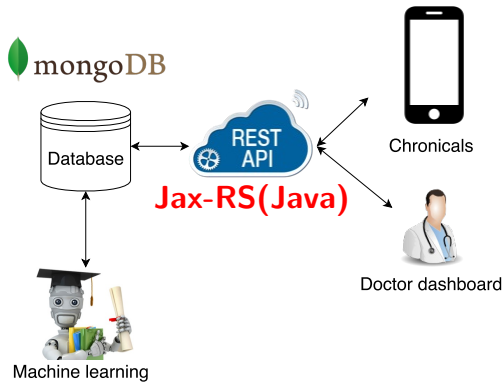
Components

- ▶ Database
- ▶ Connection to App
- ▶ Connection to Docter Dashboard
- ▶ Connection Machine learning module

System



System



Intro

Genetic merging of DT's

Platform requirements

Doctor dashboard

Mobile application

Conclusion & future work

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Many different induction algorithms



C4.5 (C5.0)



CART



QUEST

...

→ **Which tree is the most beautiful?**

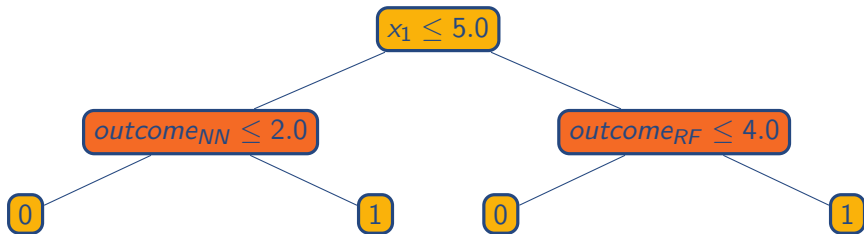
Current ensembles lack interpretability

Boosting, bagging, random forests, etc. require majority voting (classification) or mean calculation (regression) to obtain prediction



Current ensembles lack interpretability

The final decision tree obtained by **stacking** contains uninterpretable internal nodes

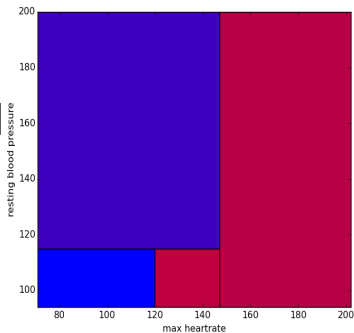
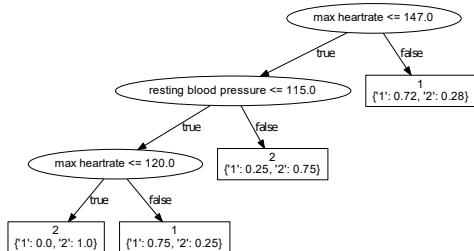


Decision tree \rightarrow decision space

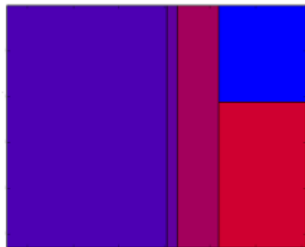
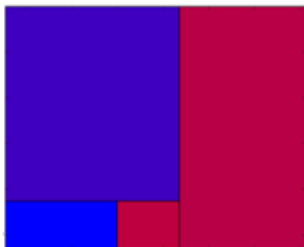
Converting decision trees to decision spaces

We can define a one-to-one mapping between a decision tree and a set of k -dimensional hyperplanes ($k = \text{\#features}$), called **decision space**. Each node in the decision tree corresponds to a hyperplane in the decision space.

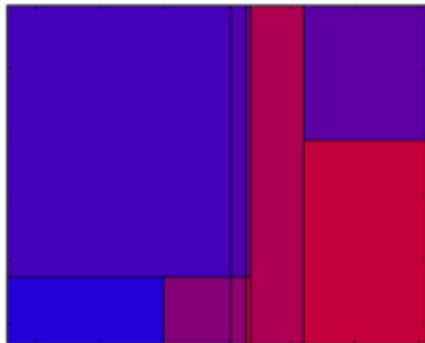
Decision tree → decision space



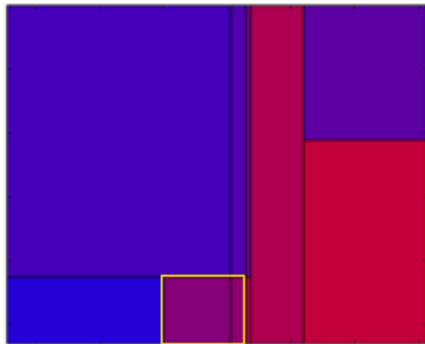
Merging decision spaces



Merging decision spaces



Pruning decision spaces

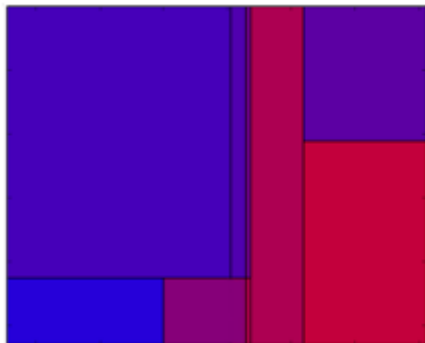


Decision space \rightarrow decision tree

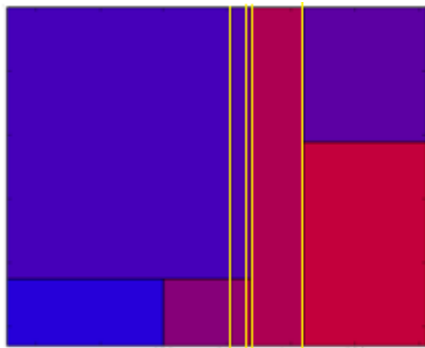
Converting decision spaces to decision trees

One-to-one mapping from decision tree to space is lost during conversion because the order is lost. Therefore, a **heuristic** approach must be taken, identifying **hyperplane candidates** and calculating a metric to choose the 'best' plane.

Decision space \rightarrow decision tree



Decision space \rightarrow decision tree

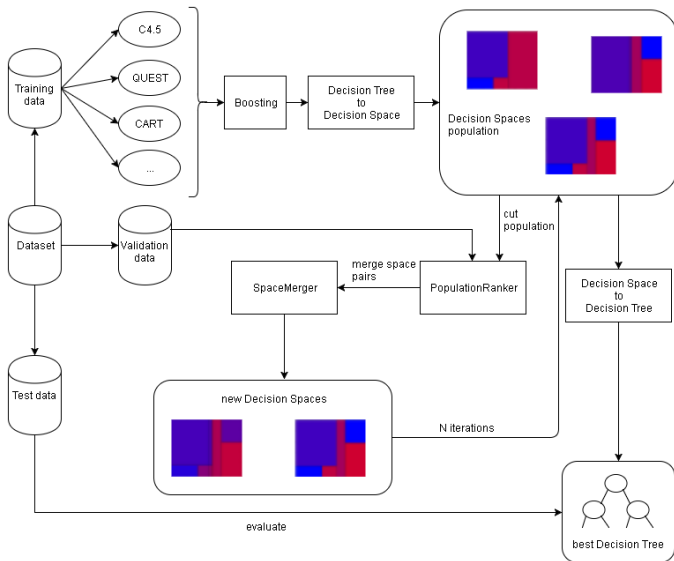


Decision space \rightarrow decision tree

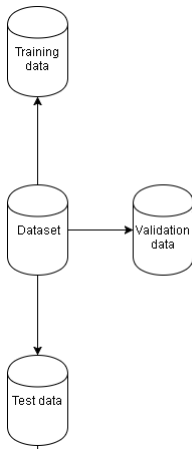
Finding 'best' candidate hyperplane

Apply metric function to each plane, these include:

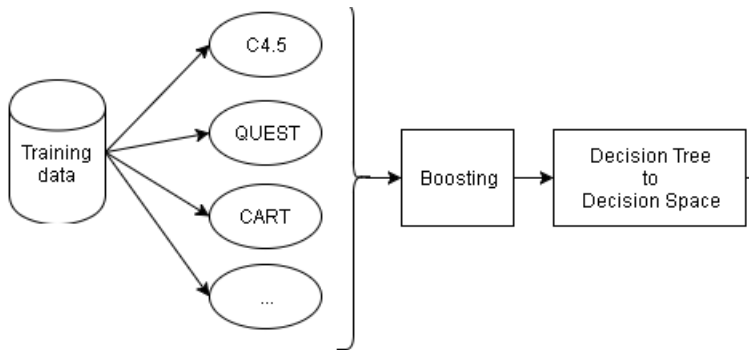
- ▶ information gain and Gini
- ▶ pick plane from most correlated feature
- ▶ pick plane that divide space in two most equal subspaces
- ▶ combination



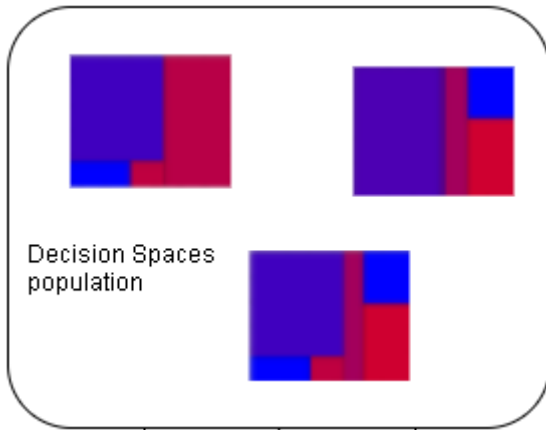
Splitting the data



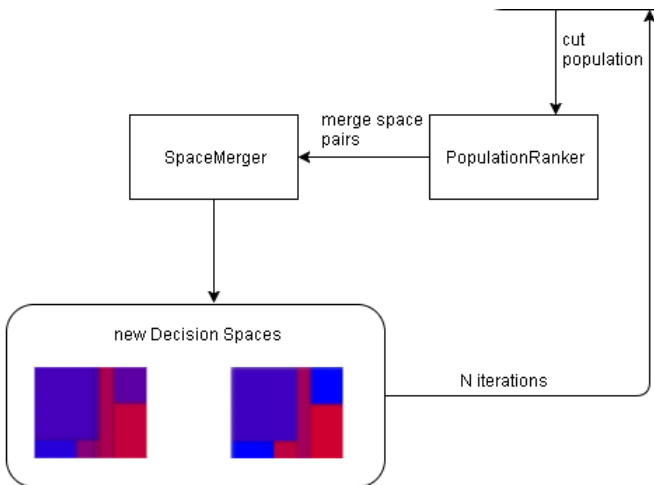
Generate different decision trees



Generate different decision trees



Genetic merging

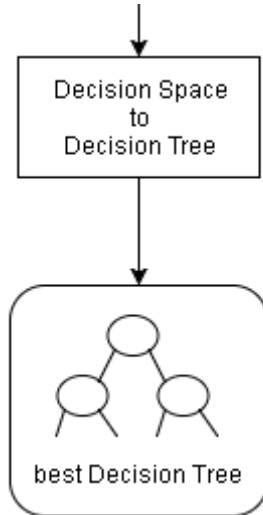


PopulationRanker

Fitness function

A high accuracy is the most important property of a decision tree, followed by its' size (\rightarrow comprehensibility). Genetic algorithms are well suited for **multi-objective optimization**.

Final iteration

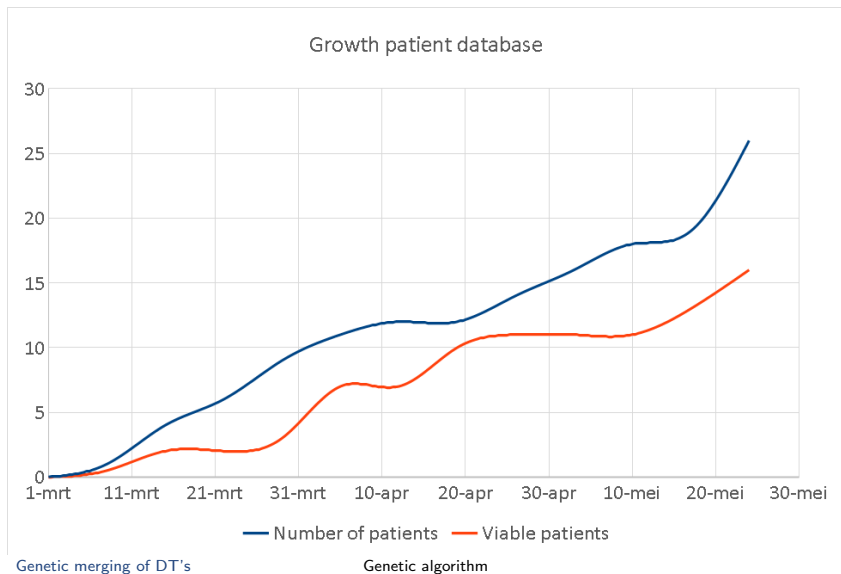


Headache dataset

Data collection could only start in March:

- ▶ the mobile application had to be finished first
- ▶ an ethical committee had to approve our application

→ too few samples for machine learning



Evaluating our algorithm

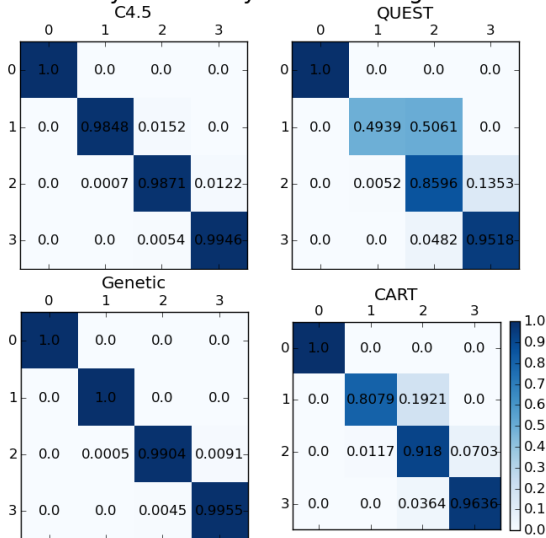
5 datasets from UCI

optimal parameters, feature selection when needed and k-fold CV

Name	#Samples	#Disc	#Cont	#Class	Imbalance rate
Heart	270	7	6	2	0.058
Car	1728	6	0	4	0.225
Iris	150	0	4	3	0
Shuttle	14500	0	9	7	0.18308
Nursery	12960	8	0	5	0.1498

Dataset	Folds	C4.5	CART	QUEST	Genetic
Heart disease	5	<u>0.8067</u>	0.7844	0.7844	<u>0.8067</u>
	10	<u>0.8104</u>	0.7732	0.7881	0.7993
Iris	3	0.9533	0.9467	0.9467	<u>0.96</u>
	5	0.9467	0.9333	0.9467	<u>0.9533</u>
Cars	3	<u>0.9722</u>	0.9693	0.9229	0.9693
	5	0.9711	0.9682	0.9241	<u>0.9786</u>
	10	0.9756	0.9751	0.9265	<u>0.9803</u>
Shuttle	3	0.9987	0.9983	0.9964	<u>0.9988</u>
	5	0.9986	0.9981	0.9962	<u>0.9988</u>
	10	0.9990	0.9987	0.9941	<u>0.9992</u>
Nursery	3	0.9890	0.9431	0.9147	<u>0.9914</u>
	5	0.9918	0.9498	0.9251	<u>0.9958</u>
	10	0.9937	0.9568	0.9259	<u>0.9954</u>

Accuracy on nursery dataset using 10 folds



Intro

Genetic merging of DT's

Platform requirements

Doctor dashboard

Mobile application

Conclusion & future work

Backend and data exposure

Doctor Dashboard

Maarten Vanden Berghe

Chronicals

- Dashboard
- Maandoverzicht
- Aanvallen**
- Statistieken
- Patiënt

≡

Andere Patiënt maarten

Aanvallen Patiënt nr. 12

Datum	Startuur	Duur	Maximum intensiteit	Medicatie
2016-04-19	04:20	1 uur 40 min	4	
2016-04-18	06:15	7 uur 45 min	3	
2016-04-12	11:47	2 uur 40 min	4	X
2016-04-10	04:46	6 uur 40 min	5	X
2016-04-07	12:00	17 uur 30 min	5	X
2016-04-07	05:30	16 uur 10 min	4	X
2016-04-03	15:07	6 uur 52 min	1	X
2016-04-03	04:00	4 uur 15 min	3	X
2016-04-01	23:10	1 dag 12 uur 50 min	7	X
2016-03-31	03:20	4 uur 5 min	5	X
2016-03-24	06:00	1 dag 7 uur 0 min	7	X
2016-03-21	21:47	9 uur 10 min	2	X

Go to page: 1 Show rows: 50 1-12 of 12

Doctor Dashboard

Maarten Vanden Berghe

Chronicals

- Dashboard
- Maandoverzicht
- Aanvallen
- Statistieken
- Patiënt

Andere Patient maarten

Maandoverzicht Patiënt nr. 12

12/2015 - 05/2016

5/2016

Dag van de maand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Intensiteit																															

4/2016

Dag van de maand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Intensiteit	7		3				4	5		5		4					3	4													
Paracetamol / Dafalgan 1000mg											2						1														
Ibuprofen / Brufen 600mg			2					1			2																				
Relert 40mg			1					1		1	1							1													

3/2016

Dag van de maand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Intensiteit																				2				5	7					5	
Ibuprofen / Brufen 600mg																														1	
Relert 40mg																								1	1						

Doctor Dashboard

Maarten Vanden Berghe



Doctor Dashboard

Maarten Vanden Berghe

Chronicals

Dashboard

Maandoverzicht

Aanvallen

Statistieken

Patiënt

maarten

maarten

Uitloggen

Dashboard

Patiënt nr. 12

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2016-04-12	11:47	2 uur 40 min	4
2016-04-10	04:46	6 uur 40 min	5
2016-04-07	12:00	17 uur 30 min	5

1-5 of 12

Datum	Uur	Medicatie
2016-04-19	07:30	Relert 40mg
2016-04-18	12:59	Paracetamol / Dafalgan 1000mg
2016-04-12	14:08	Ibuprofen / Brufen 600mg
2016-04-12	08:00	Paracetamol / Dafalgan 1000mg
2016-04-12	13:30	Paracetamol / Dafalgan 1000mg

1-5 of 16

Intro

Genetic merging of DT's

Platform requirements

Doctor dashboard

Mobile application

Conclusion & future work

Backend and data exposure

Conclusion

- ▶ It is shown that the current process in the UH of Ghent can be completely digitized. Our solution can significantly improve the efficiency and reduce the frequency of consults, leading to a reduction in health care costs.
- ▶ The foundations for a diagnosis support system are built, using a genetic approach to merge different induced decision trees to obtain a single decision tree with enhanced accuracy.

Future work

- ▶ Develop native applications for iOS and Android to enhance look-&-feel
- ▶ Re-evaluate our machine learning models on a larger headache dataset
- ▶ Implement more induction algorithms and ensemble techniques to create a more diverse initial population
- ▶ Experiment with other selection techniques and fitness functions
- ▶ Optimize the heuristic approach to convert decision spaces to decision trees

Thank you for your attention!

Intro

Platform requirements

Mobile application

Backend and data exposure

Genetic merging of DT's

Doctor dashboard

Conclusion & future work