

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

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Faculty of Engineering and Architecture

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Machine learning - DT's

Platform requirements

Genetic merging of DT's

Mobile application

Visualization

Backend and data exposure

Conclusion & future work

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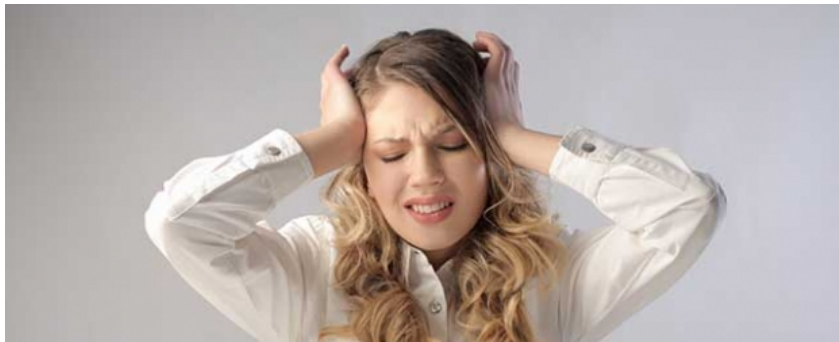
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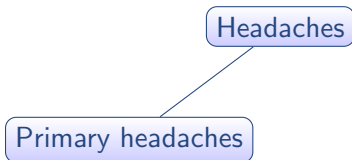
# Introduction



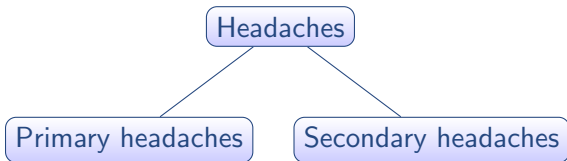
# Headaches

Headaches

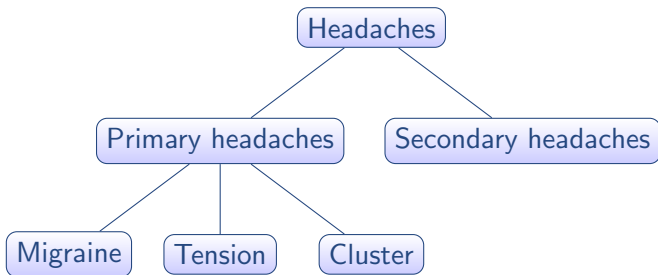
# Headaches



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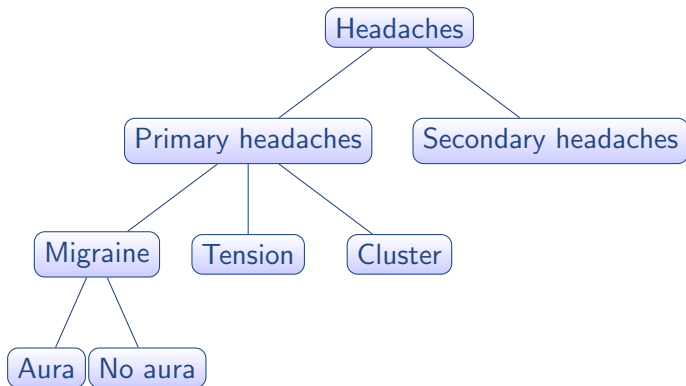


# Headaches





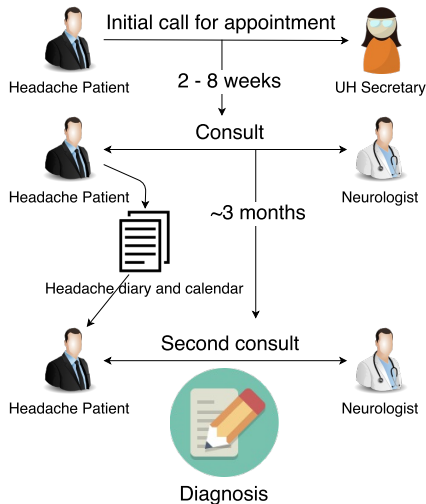
# Headaches



# 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)

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# Platform requirements

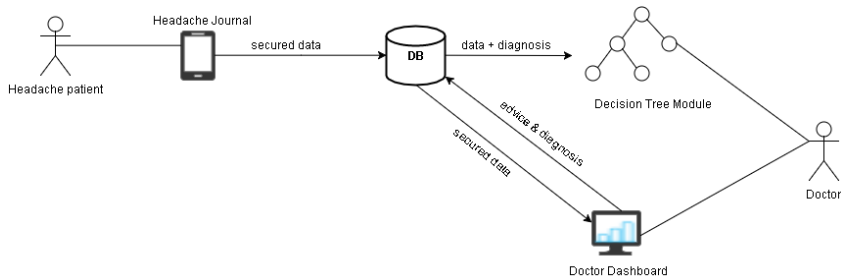
Our proposed alternative consists of:

- ▶ Headache journal: mobile app
- ▶ Doctor Dashboard: web application
- ▶ Machine learning module: auto-classify

Solution non-functional requirements:

- ▶ Security
- ▶ Availability
- ▶ Performance
- ▶ Usability

# Platform requirements



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# Mobile Application

Why create a new application?

## Competition

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

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All good, but:

# Mobile Application

Why create a new application?

## Competition

- ▶ Migraine Buddy
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All good, but:

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

# Development paradigms

Different kinds of approaches for mobile application development:

- ▶ Web application
- ▶ Hybrid application
- ▶ Native application

→ How do we choose?

# Web application

Webapps are developed once and can be viewed on (almost) all smartphones (via built-in web engine).

- + “write once, run everywhere”  $\Rightarrow$  lower cost
- + No installation required
- limited use of device specific features (GPS, camera, ...)
- **Not all devices same web engines  $\Rightarrow$  other view**
- No native look and feel

$\Rightarrow$  **No web application**

## Native application

Native apps are developed once for each OS and installed on the device.

- + Best performance (optimized machine code at compile time)
- + Device specific features usable (GPS, camera, ...)
- + Native look and feel
- **Write code for each OS (very costly dev + maintenance)**
- Installation required

⇒ Native application?

## Hybrid application

Hybrid apps are developed once and installed on the device. It uses the devices internal web engine, but has more control than web applications.

- + “write once, run everywhere”  $\Rightarrow$  lower cost
- + Better performance (semi-optimized machine code)
- + Device specific features usable (GPS, camera, ...)
- + Native look and feel (using libraries)
- Installation required
- **Not all devices same web engines  $\Rightarrow$  other view (but manageable)**

$\Rightarrow$  **Hybrid application?**

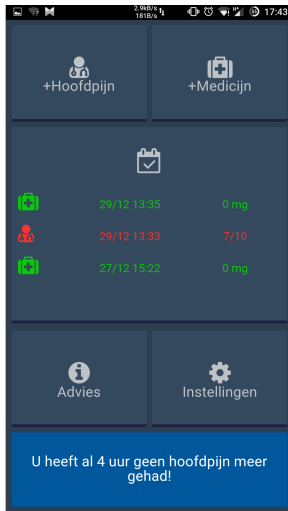
## Hybrid vs Native

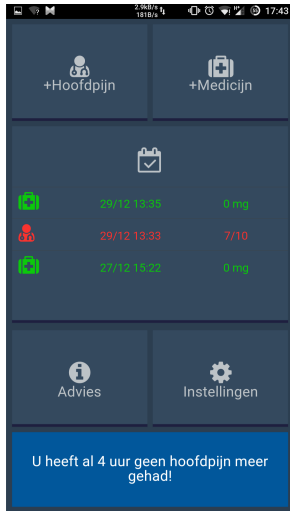
	Native	Cross-platform
+	<ul style="list-style-type: none"> <li>+ Native UX</li> <li>+ device-specific features</li> <li>+ Better performance</li> </ul>	<ul style="list-style-type: none"> <li>+ 1 language</li> <li>+ Write once, run everywhere</li> <li>+ Less maintenance</li> </ul>
-	<ul style="list-style-type: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



## Hybrid vs Native

	Native	Cross-platform
+	<ul style="list-style-type: none"> <li>+ Native UX</li> <li>+ device-specific features</li> <li>+ Better performance</li> </ul>	<ul style="list-style-type: none"> <li>+ 1 language</li> <li>+ Write once, run everywhere</li> <li>+ Less maintenance</li> </ul>
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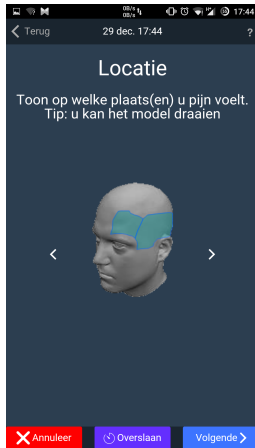
# Chronicals



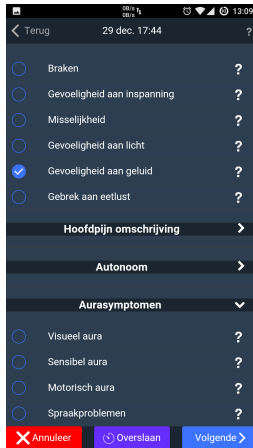
# Chronicals



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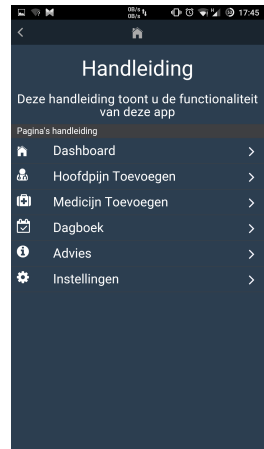
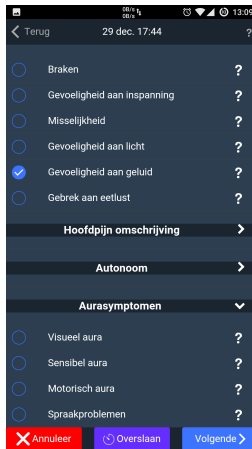
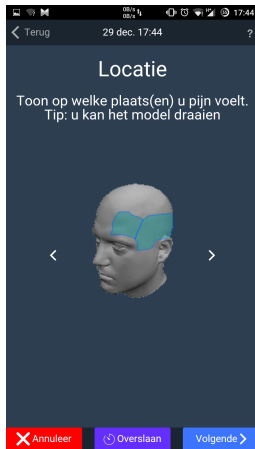


Mobile application



Chronicals

# Chronicals



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# Many different induction algorithms



C4.5 (C5.0)



CART



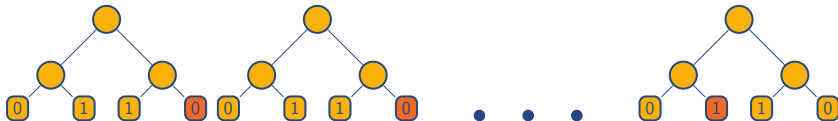
QUEST

...

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

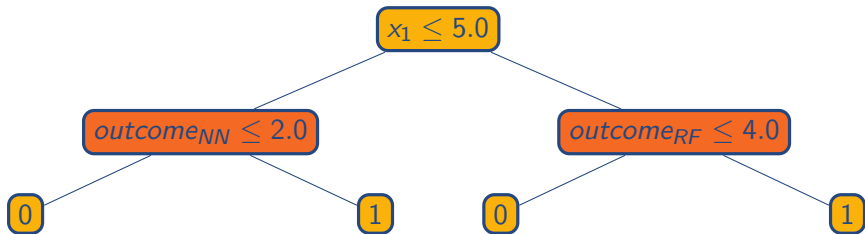
# Current ensembles lack interpretability

**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

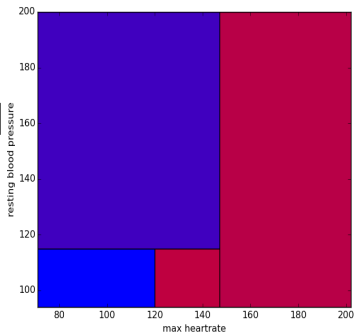
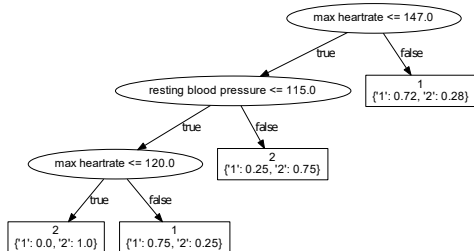


## Decision tree $\rightarrow$ decision space

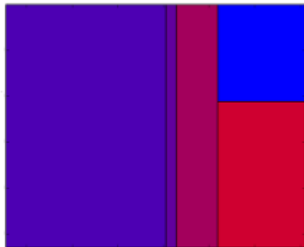
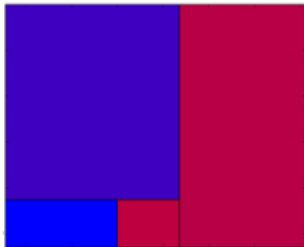
### Converting decision trees to decision spaces

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.

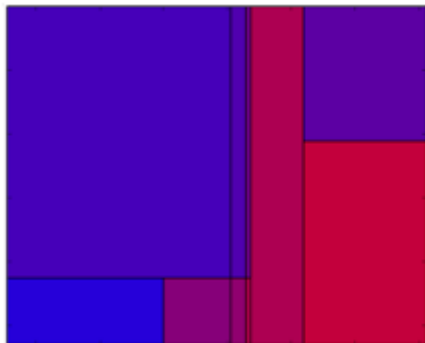
## Decision tree → decision space



# Merging decision spaces

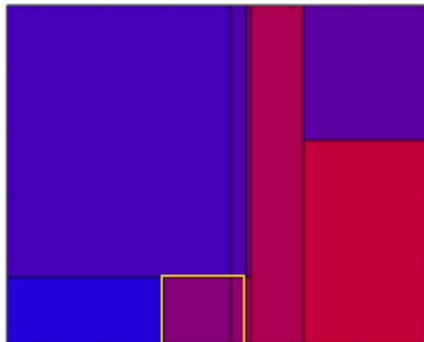


# Merging decision spaces





# Pruning decision spaces



## Decision space $\rightarrow$ decision tree

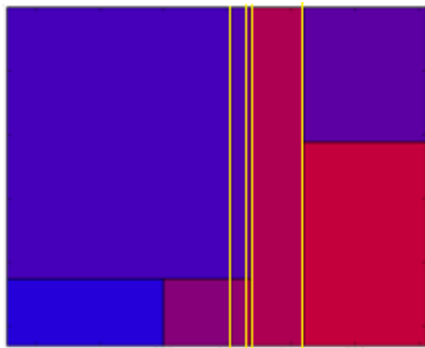
### Converting decision spaces to decision trees

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.

### Candidate hyperplanes

In order for a plane to be the next candidate node, it must be unbounded in all dimensions but one.

## Decision space $\rightarrow$ decision tree

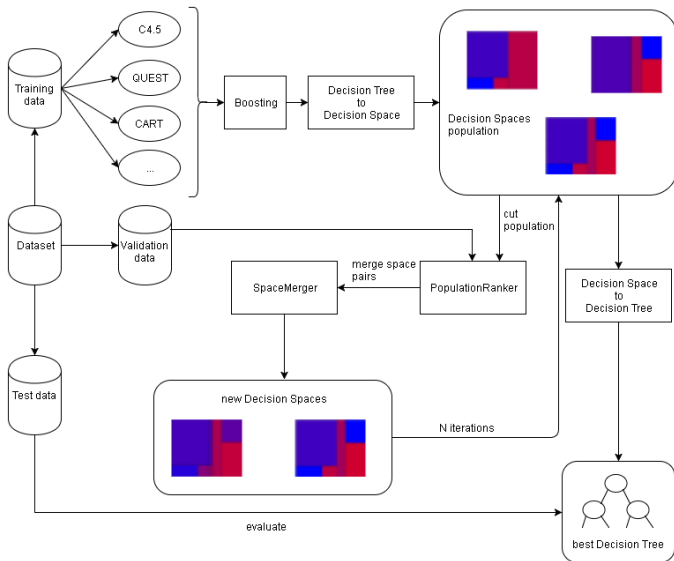


## Decision space $\rightarrow$ decision tree

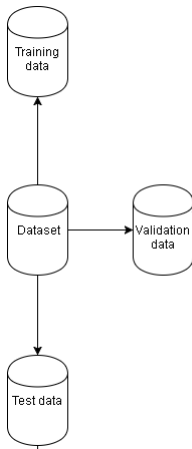
### Finding 'best' candidate hyperplane

Apply metric function to each plane, these include:

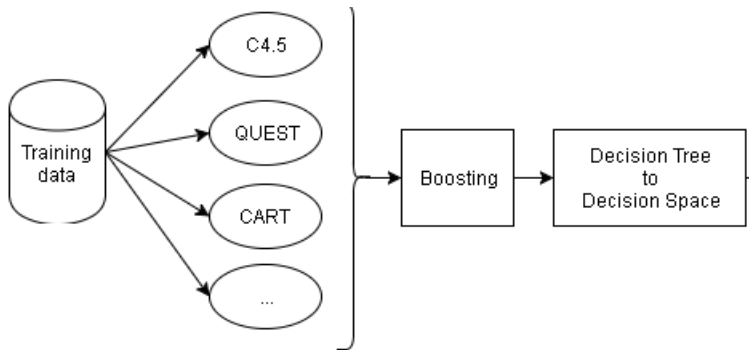
- ▶ information gain and Gini from C4.5 and CART respectively
- ▶ pick plane from most correlated feature ( $\chi^2$ - and ANOVA  $F$ -test from QUEST)
- ▶ pick plane that divide space in two most equal subspaces (using surface/volume or counting number of planes)
- ▶ combination



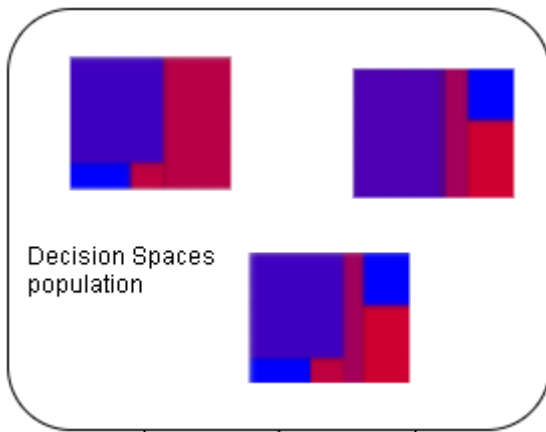
## Splitting the data



## Generate different decision trees

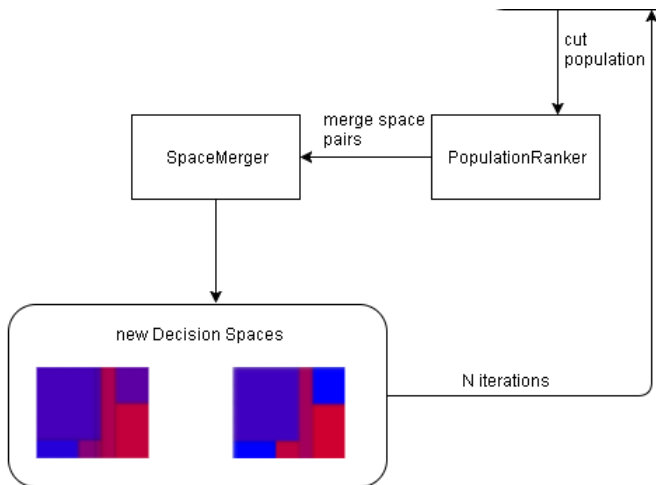


## Generate different decision trees

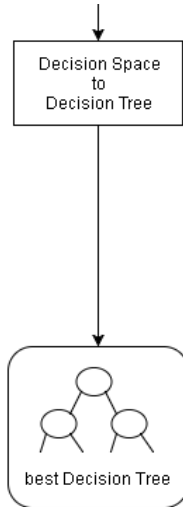




## Genetic merging



## Final iteration



# Evaluating our algorithm

5 datasets from UCI  
optimal parameters, feature selection when needed and k-fold  
cross-validation

## Heart disease dataset



- ▶ medical dataset
- ▶ 270 samples
- ▶ 13 features: 6 continuous (max heartrate), 7 discrete (sex)
- ▶ 2 classes: sick or healthy
- ▶ more healthy than sick samples
- ▶ false negatives can cost lives!

## Car evaluation dataset



- ▶ 1725 samples
- ▶ only 6 features, all categories (price, doors, ...)
- ▶ 4 classes: unacceptable, acceptable, good and very good
- ▶ VERY imbalanced (70% unacc, 22.2% acc)

## Iris flowers dataset



- ▶ very small dimensions
- ▶ 150 flowers
- ▶ 4 continuous features (petal width and sepal length)
- ▶ 3 classes: setosa, versicolor, virginica
- ▶ perfectly balanced (50-50-50)

# Shuttle classification dataset



- ▶ originally: 58000 samples corresponding to aircrafts
- ▶ here: 14500 samples
- ▶ 9 numerical attributes
- ▶ 7 different types of shuttles: 2 of them contained less than 10 samples (discarded)

# Nursery application dataset

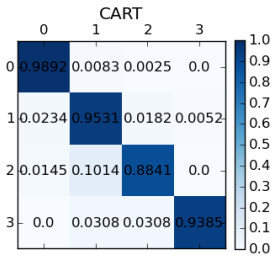
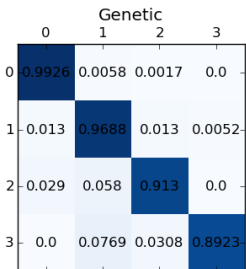
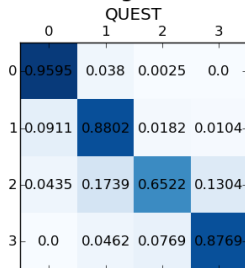
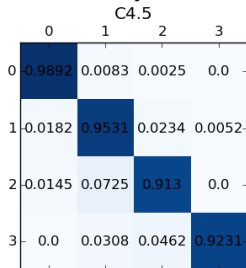
- ▶ 12960 samples (applications for nursery school)
- ▶ 8 categorical features
- ▶ 5 classes: not recommended, recommended, very recommended, priority and special priority
- ▶ only 2 samples were recommended (discarded)



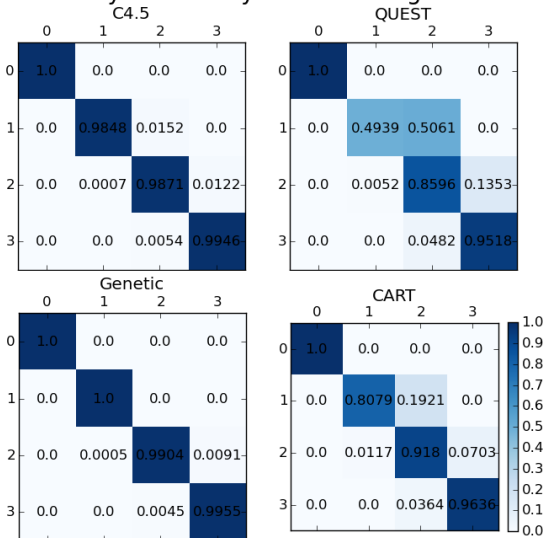


Dataset	Folds	C4.5	CART	QUEST	Genetic
Heart disease	5	<u><b>0.8067</b></u>	0.7844	0.7844	<u><b>0.8067</b></u>
	10	<u><b>0.8104</b></u>	0.7732	0.7881	0.7993
Iris	3	0.9533	0.9467	0.9467	<u><b>0.96</b></u>
	5	0.9467	0.9333	0.9467	<u><b>0.9533</b></u>
Cars	3	<u><b>0.9722</b></u>	0.9693	0.9229	0.9693
	5	0.9711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

## Accuracy on cars dataset using 10 folds



## Accuracy on nursery dataset using 10 folds



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## Bedankt

### Bedank voor uw aandacht

No written word,  
No spoken plea,  
Can teach the youth what they should be,  
Nor all the books on all the shelves,  
It's what the teachers are themselves

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