Electronic Noses with Neural Networks for Odour Quality and Quantity

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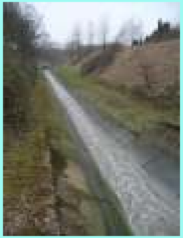
F) Conclusion

Problem: Odour from canalization

Odour can not be assigned to a special substance

Responsible for odour:

- oxygen
- nitrate
- organic material
- sulphur and sulphur chemical compounds

The human nose doesn`t smell only one substance.

The odour in canalization depends on a lot of factors:
- temperature
- raining water
- industrial water
- quantity of organic material
- velocity of water

In most cases we can only measure the situation at a time point, but not for a longer time period.

Problem: Avoiding odour

Avoiding odour

- **oxygen, 0_2**

Disadvantage: High fire danger

- **hydrogene peroxide H_2O_2**

I
Disadvantage : acidly

- **Calciumnitrat [NUTRIOXÂ®]**

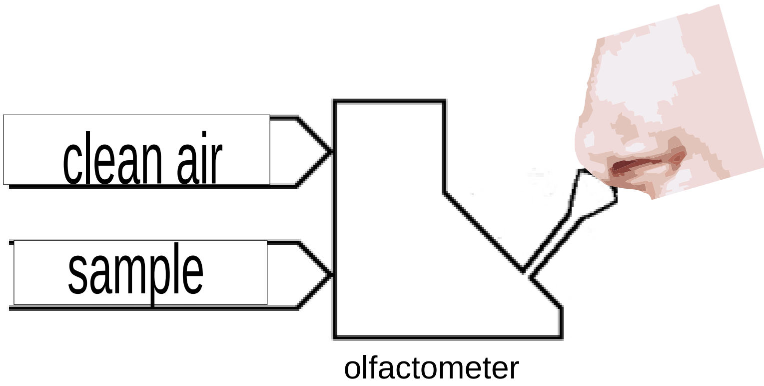
Disadvantage : adorable

Costs: NUTRIOXÂ® is sucessfull. The costs are 0.3 € / m³ water

- Mask of odour etc.

for avoiding odour we have to determine the odour quantity

Olfactometric measurement



Olfactometry: objective measurement of odour

Disadvantage:

- High costs
- Only a measurement for one time point

Unit
The odour unit is defined at the barrier of the concentration of the sniffable material
1 Odour unit (OU/m³) (DIN EN 13725 / VDI - RICHTLINIE 3881)
The test person informs us about the lowest concentration he can smell.
Difficulty: • Differences between test persons
• Adequacy of test persons

Solution for a continuous measurement

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There are three different kinds of sensor measurement:

- oscillating crystals
- electrical resistance
- optical measurement

for an unspecific measurement all methods are comparable with each other.

(for application in a big city (more than 1,5 Mio inhabitants) we decide to take the electrical resistance.

The electronic nose consists on many sensors.

The signals has to be interpreted for odour.

Necessary: An assignment f (sensorsignals) =odour quantity

We need a suitable mathematical procedure

Preprocessing for mathematical procedures

The continuous measurement of the electronic nose has to be assigned to an olfactrometic measurement*

Together with the company for canalization we have to find a barrier for a critical value of odour quantity
**

500 OU/m^3

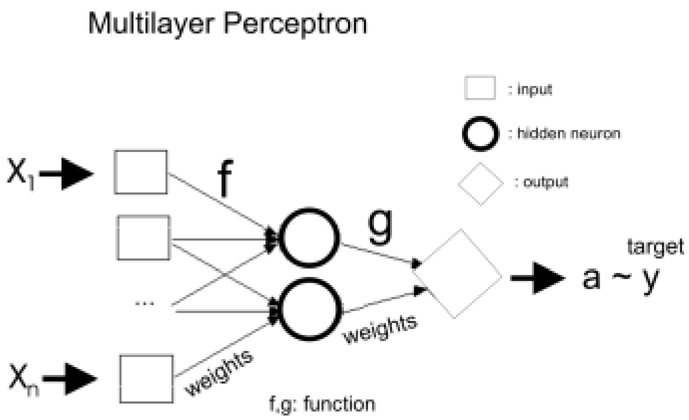
„>“ / „1"

„<“ / „0"

* After 5 hours there could be a difference between the olfactometric measurements and sensor signals

**We have no measurement with an exact value of 500 OU/m^3

Neural networks



Irrelevant: Statement about one sensor

Relevant: Interaction between sensors

P(barrier > x| Sensorsignals)= p

Under the conditions of sensorsignals we get a probability

<u>Further more: Non-linearity of concentrations</u>

Neural networks Algorithm

Step 1. $E = \sum_{k=1}^{N} (\tilde{y}_k - y_k)^2$

Differences between estimation and reality

<u>Aim:</u> Minimum of error E

Step 2. $z_j = g(\sum_{i=1}^{n} w_i \cdot x_i)$

Hidden layer (Sigmoid-function)

Step 3. $a = h(\sum_{j=1}^{m} u_j \cdot z_j)$

Output layer (Sigmoid-function)

Step 4. $\tilde{y} = F(a)$

Function for output (Interpretation)

Step 5. $w_i^{new} = w_i^{old} + \alpha \cdot \Delta w_i$

Initialisation of raise in hidden layer

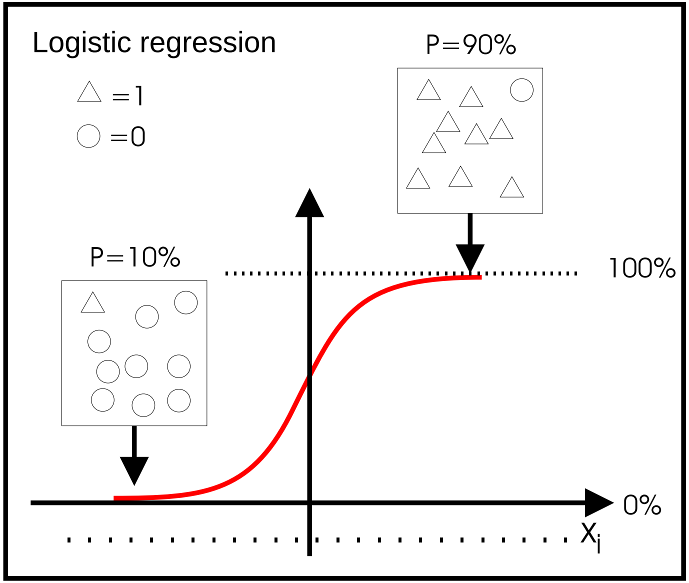
back propagation ↕

At start: random weights

Step 6. $u_j^{new} = u_j^{old} + \alpha \cdot \Delta u_j$

Initialisation of raise in output layer

Application of Logistic regression



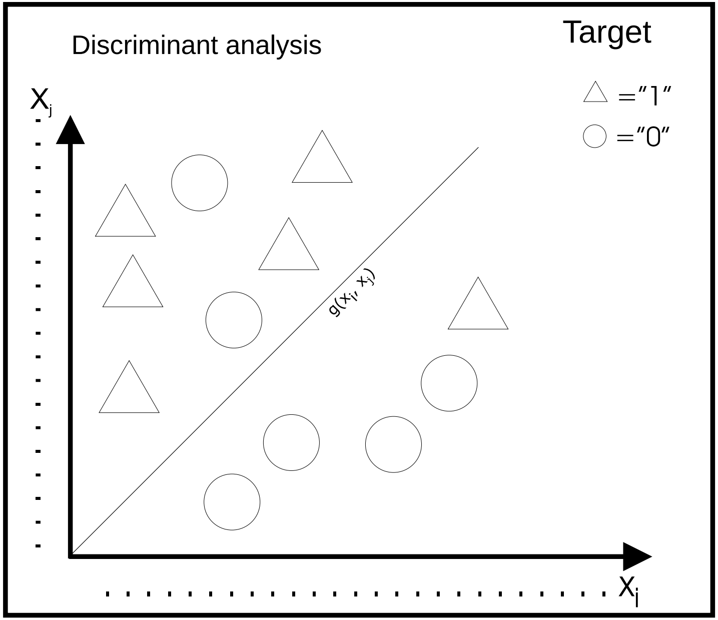
Irrelevant: Interaction of sensors

Relevant: assignment

Similiar to one-layer neural network

P(barrier> x| barrier)= p

Application of Discriminant analysis



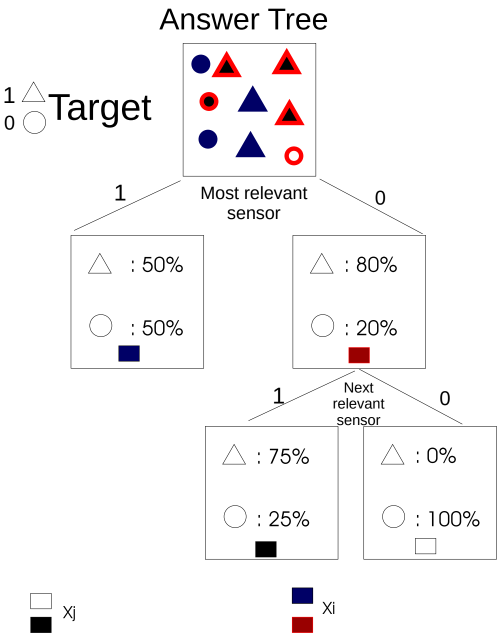
Irrelevant: No results for interaction between sensors

Relevant: statement for the assignment to a category

f(Sensorsignals)= y
y > critical value ➡ ***odour quantity = „1"***
y < critical value ➡ ***odour quantity = „0"***

Only linear seperation

Application of Answer Tree



Irrelevant: multivariate

Relevant: Finding a decision tree

Example:
Cut-off for target and sensor signals

Most relevant Sensor „5" = 0 and next relevant Sensor „4" = 1 ➡ odour quantity „1" with a probability 75 %

Easy to handle for the engineers

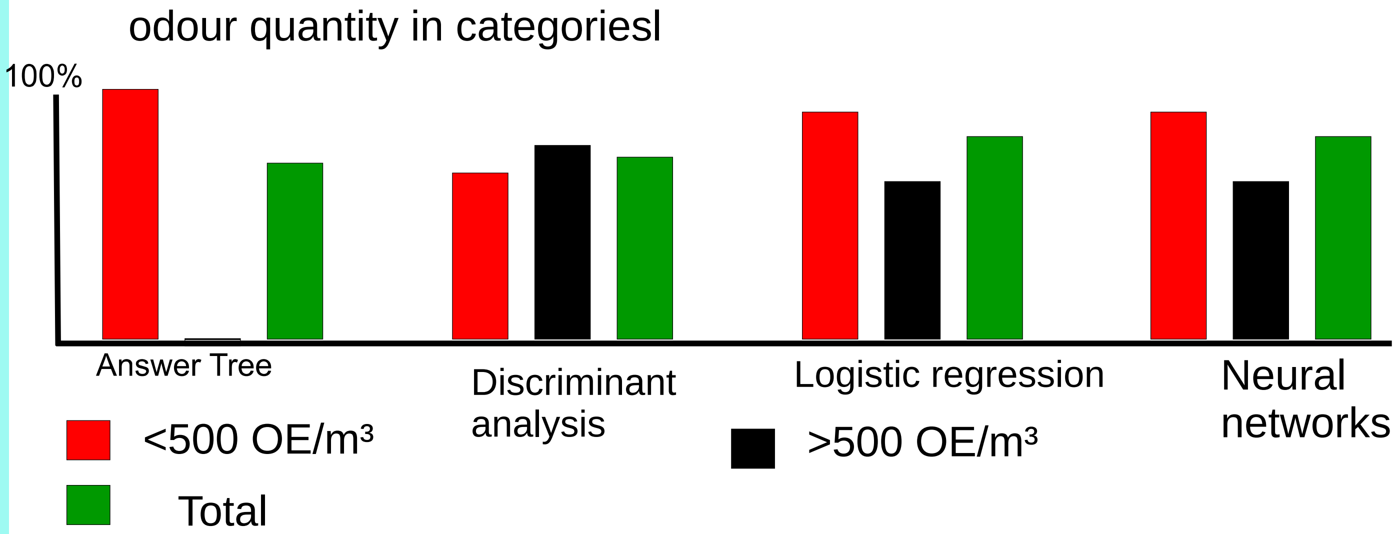
Either you determine the cut off- value (CHAID) or it could be determined by the procedure (CRT)

Results for Explanation*
(n_1=57 measurements)

	<500 OE(m³	>500 OE/m³	Total
Neural network	11 (64,7 %)	35 (87,5 %)	46 (80,7 %)
Logistic regression	11 (64,7 %)	35 (87,5 %)	46 (80,7 %)
Discriminant analysis	13 (76,4 %)	27 (67,5 %)	40 (70,2 %)
Answer Tree	0 (0 %)	40 (100 %)	40 (70,2 %)

*Explanation: Using the known data

Explanation (n1=57 measurements) *



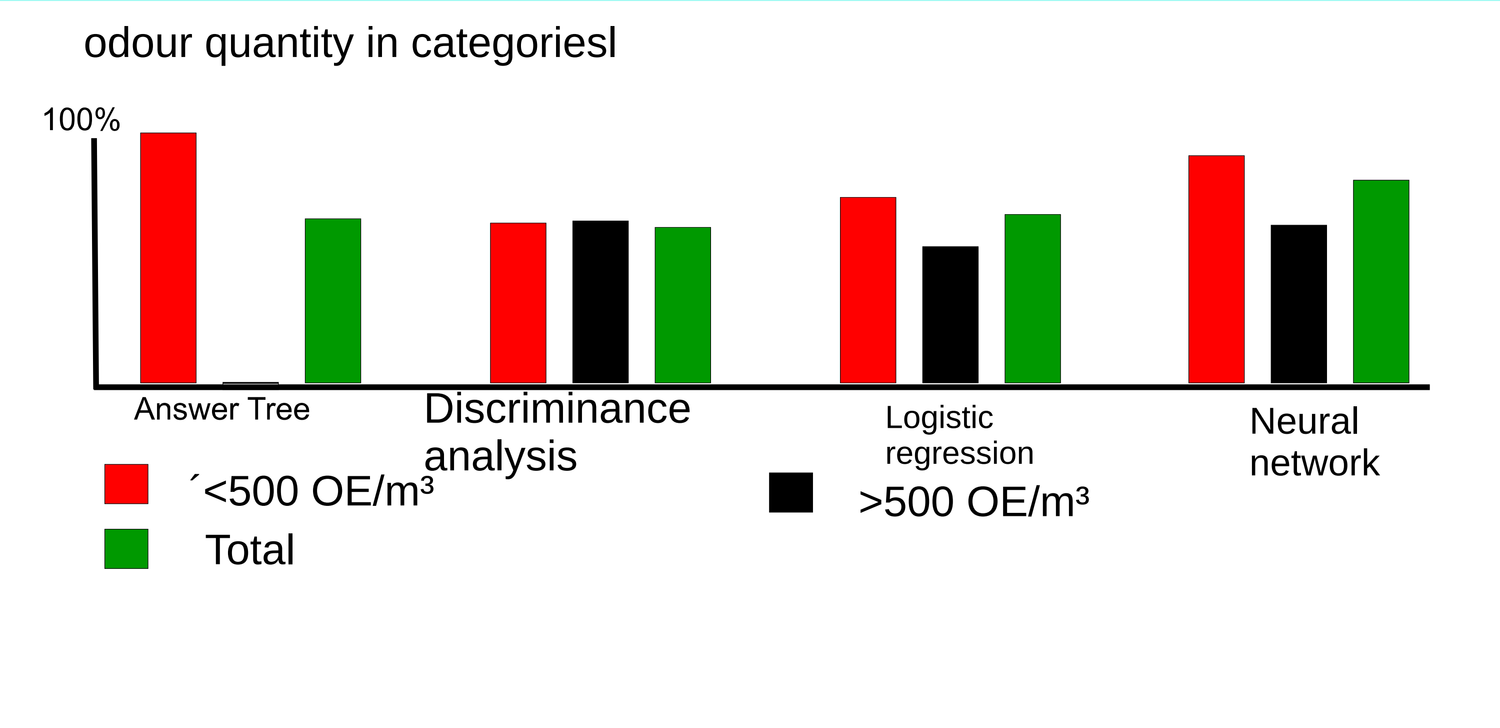
*Explanation in one part of the sample (ca. 50%)

Prediction *
(n_2=58 measurements)

	<500 OE(m³	>500 OE/m³	Total
Neural networks	17 (68%)	30 (90,8%)	47 (81%)
Logistic regression	13 (52%)	26 (78,8%)	39 (67,2%)
Discriminance analysis	18 (72%)	24 (72,7%)	40 (70,2%)
Answer Tree	0 (0%)	40 (100%)	40 (70,2%)

*Prediction on unknown data: Validation

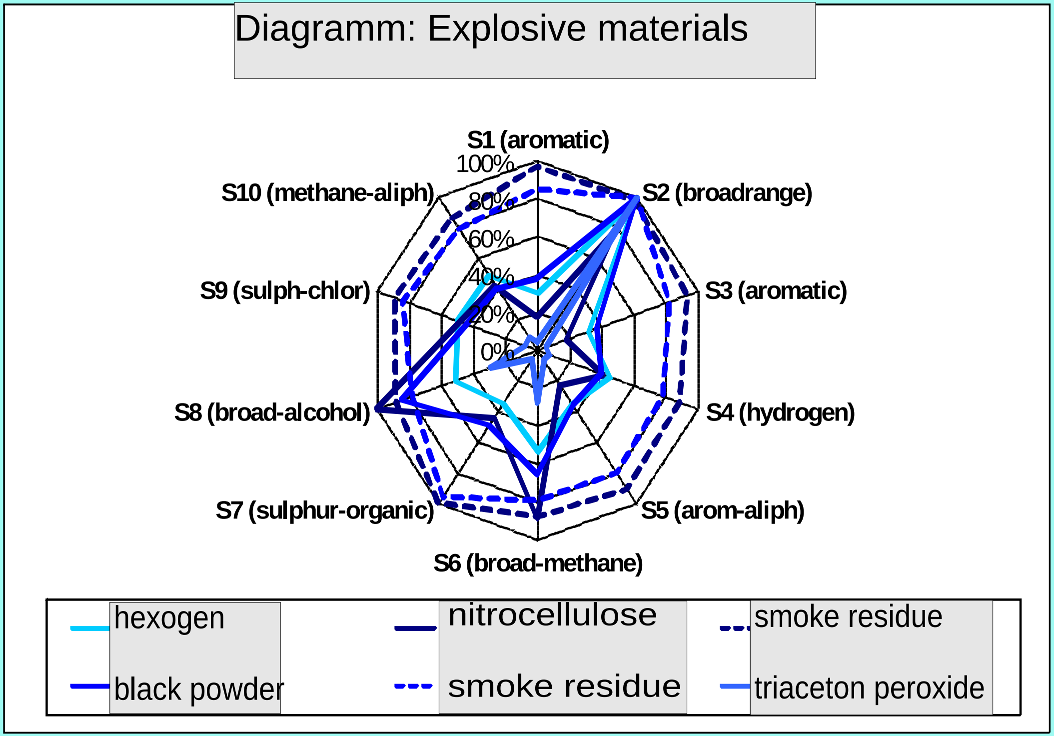
Prediction
(n_2=58 measurements)



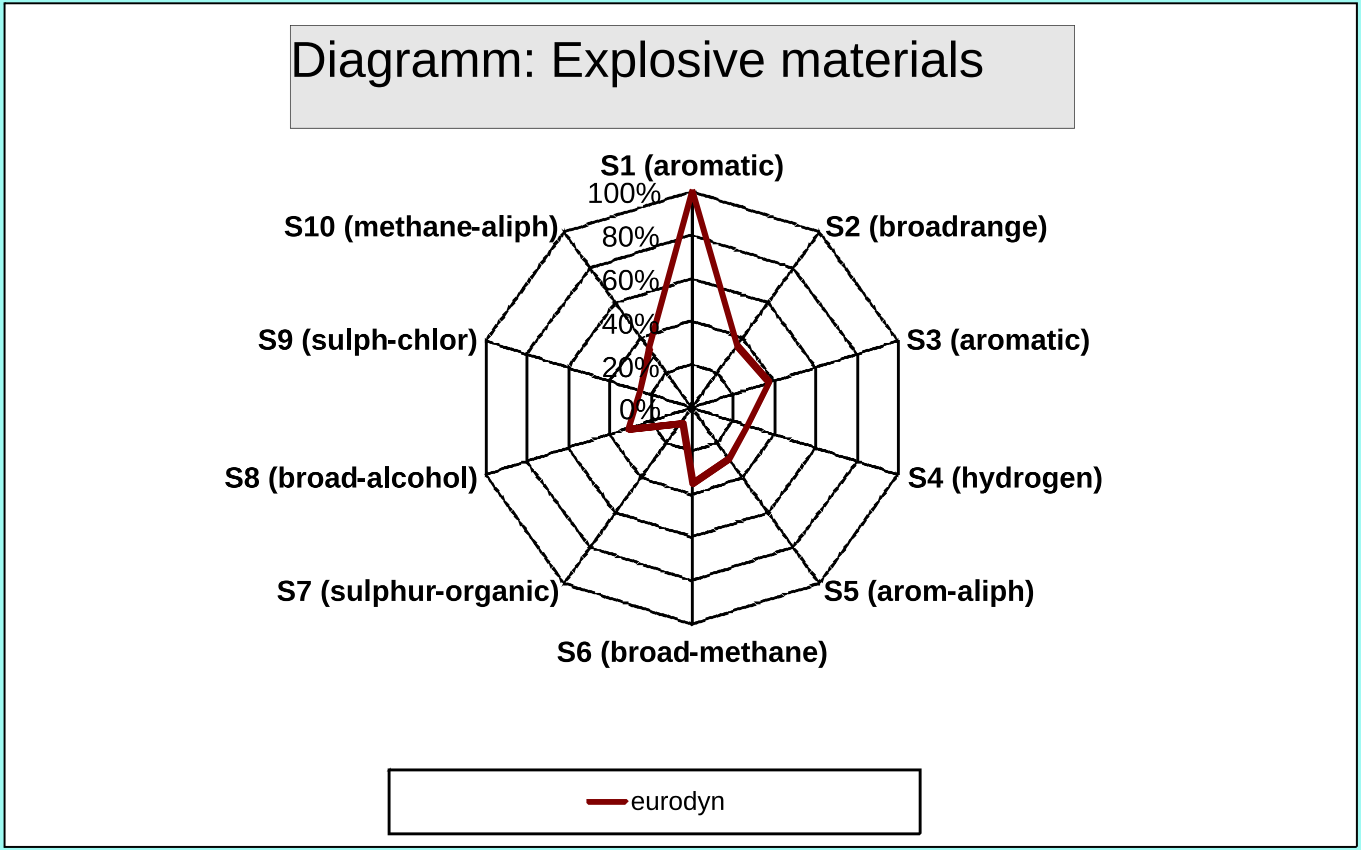
Prediction on unknown data : Validation

Shape Analysis for odour quality

Explosive materials



Shape Analysis for Odour quality



Conclusion

- All procedures are usefull for estimation the odour quantity

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- For Answer Tree you have only a reduced number of sensors

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- Shape Analysis is usefull for odour quality

Forecast

- More measurements
- Improvement of measurements (on time olfactometric measurements)
- Odour Profiles for every substance and mixture of substances

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