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# Potential use of mid-infrared milk spectrum in pregnancy diagnosis of dairy cows

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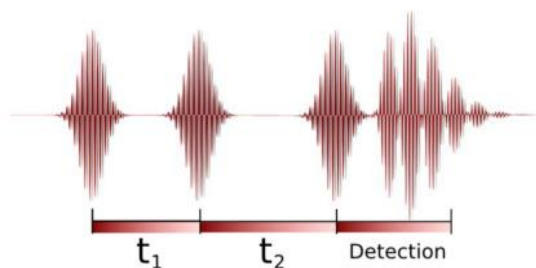
# Context



- OptiMIR project:
  - 17 European partners → Common database
  - Milk recording organizations, research centers, milk analysis laboratory

*„New tools for a more sustainable dairy sector“*

- Based on mid-infrared spectral information from milk



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- Fertility
- Feeding
- Health
- Rejection of pollutants
- Milk quality



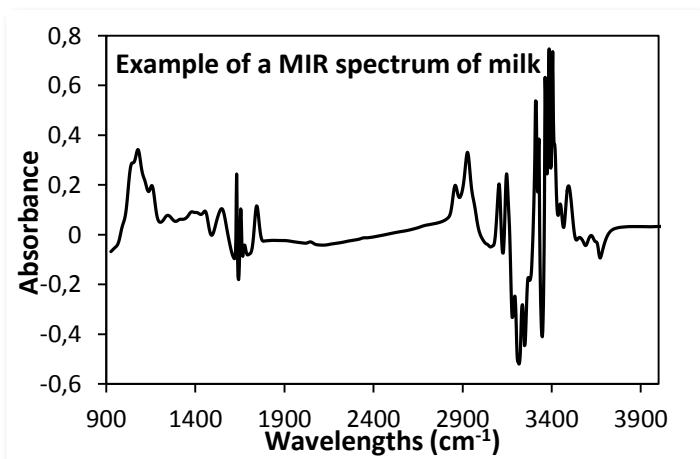
# Context

Milk recording



Mid-Infrared Spectroscopy  
(MIR)

Spectral database  
(>5,000,000 spectra)

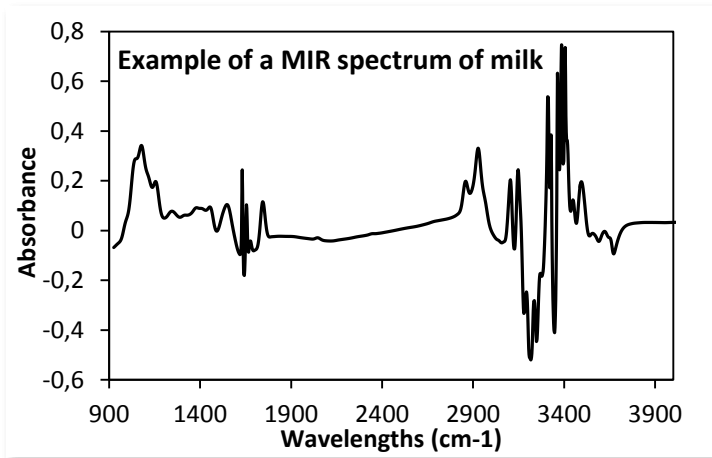


**Major components:** Fat,  
protein, lactose, urea

**Fine milk composition:** Fatty  
acids, minerals, lactoferrin, ...



# Objectives



**Direct response from  
the MIR spectrum  
about the animal  
status**



- Identification of a spectrum coming from a pregnant cow or an open cow → **Pregnancy Diagnosis**
  - Important cost for the dairy sector
  - Milk recording organizations

*Does the observed MIR spectrum  
belong to a pregnant cow or not ?*

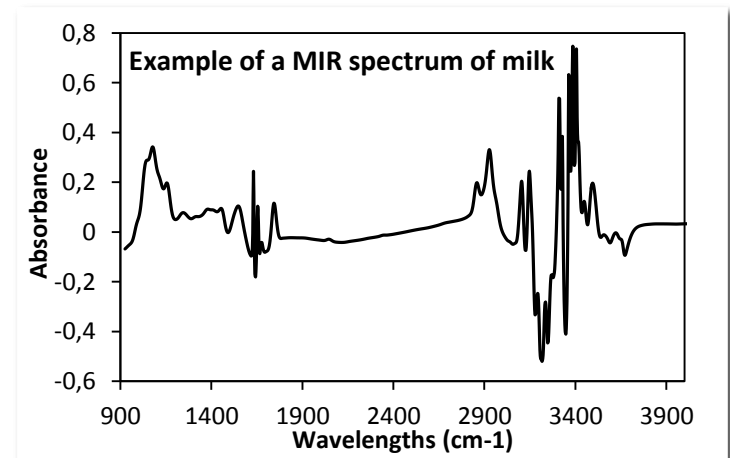
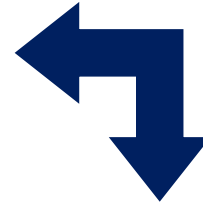
# Principles

- Many factors influence the shape of the milk MIR spectra:
  - Days in Milk, Parity, Breed, Farm management, ...

→ *How to observe differences in spectra due to the pregnancy ?*

- Literature examples :

- Sloth et al. 2003: Adjustment of milk parameters on a subset of healthy samples applied on a whole dataset (healthy and not) to assess udder health from milk samples
- Staib et al. 2001: Diagnosis of rheumatoid arthritis with discriminant analysis on human blood IR spectra



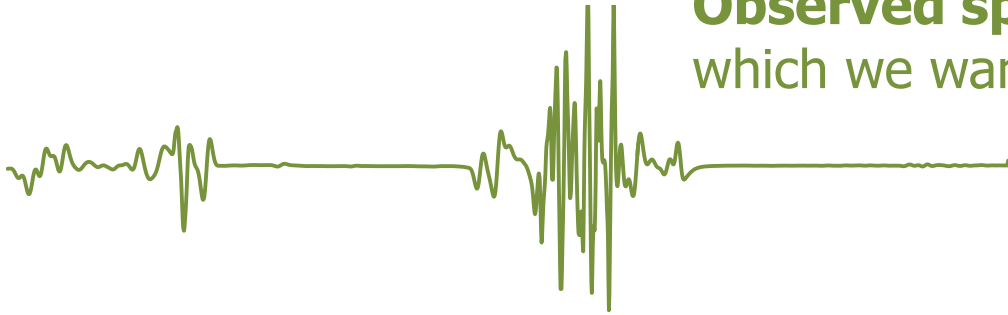
# Principles

**Observed spectrum** = Milk sample on which we want to test the pregnancy



# Principles

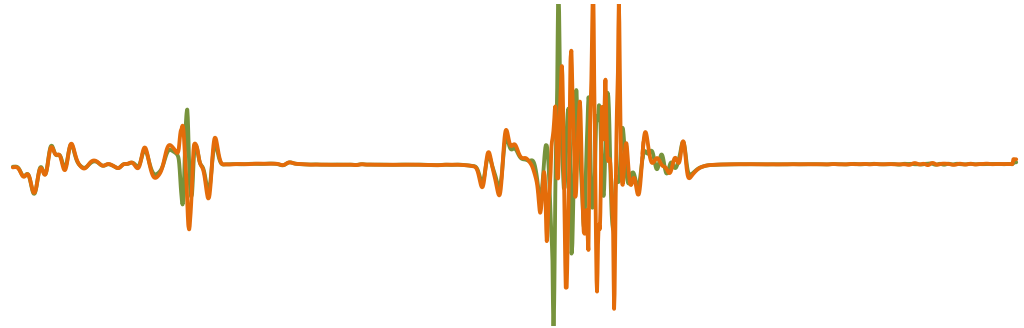
**Observed spectrum** = Milk sample on which we want to test the pregnancy



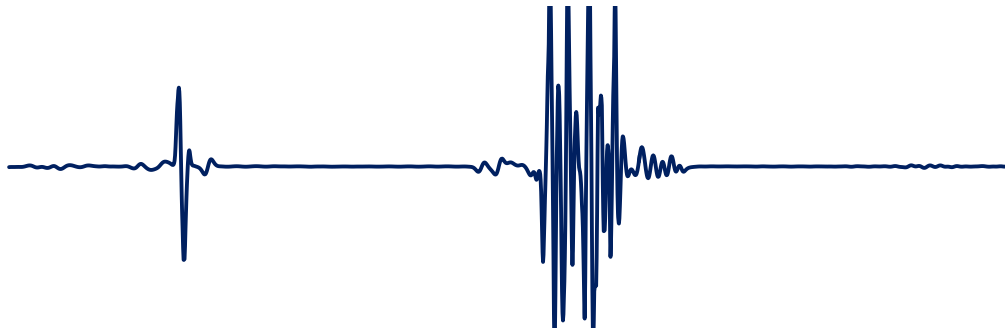
**Expected spectrum** = Expected spectrum for the same day in milk if the animal was not pregnant



# Principles



$$\text{Residual spectrum} = \text{Observed spectrum} - \text{Expected spectrum}$$



Reproductive status  
Unaccounted factors  
Errors

Residual spectra are used to perform discrimination between two groups of classification (Pregnant cow and non-pregnant cow)



# Data

- Dataset from **Walloon Region of Belgium**
  - 388,951 observations = spectra
  - TD from January 2010 to December 2012 → **3 years**
  - Only lactations that started within the period
  - At least 1 observation per animal x lactation for which the cow is open
- Pre-processing of MIR spectra
  - First derivative: Set all spectra to a common baseline
  - Informative area: Avoid noises and non-useful area
- Modeling an expected spectrum which is based on history of the animal
  - Animal, parity, breed, days in milk, ...
  - Modeling based on a **subset of non-pregnant data**: 197,109 spectra



# Data

- Discriminant analysis
  - Groups of classification: **Pregnant** and **Non-pregnant**
  - Predictors: **Residual spectral points**
- Training set = construction of the discriminant equation
  - TD from January 2010 to December 2011 → **2 years**
  - Maximum 120 days after the insemination
  - 217,148 observations (36.6% pregnant & 63.4% non-pregnant)
- Validation = test data for applying the discriminant equation
  - TD from January 2012 to December 2012 → **1 year**
  - TD from lactations that started after 1<sup>st</sup> January 2012
  - Maximum 120 days after the insemination
  - 51,109 observations (15.0% pregnant & 85.0% non-pregnant)

# Results

Specificity = 96.8% (NP observations correctly classified)

Sensibility = 77.0% (P observations correctly classified)

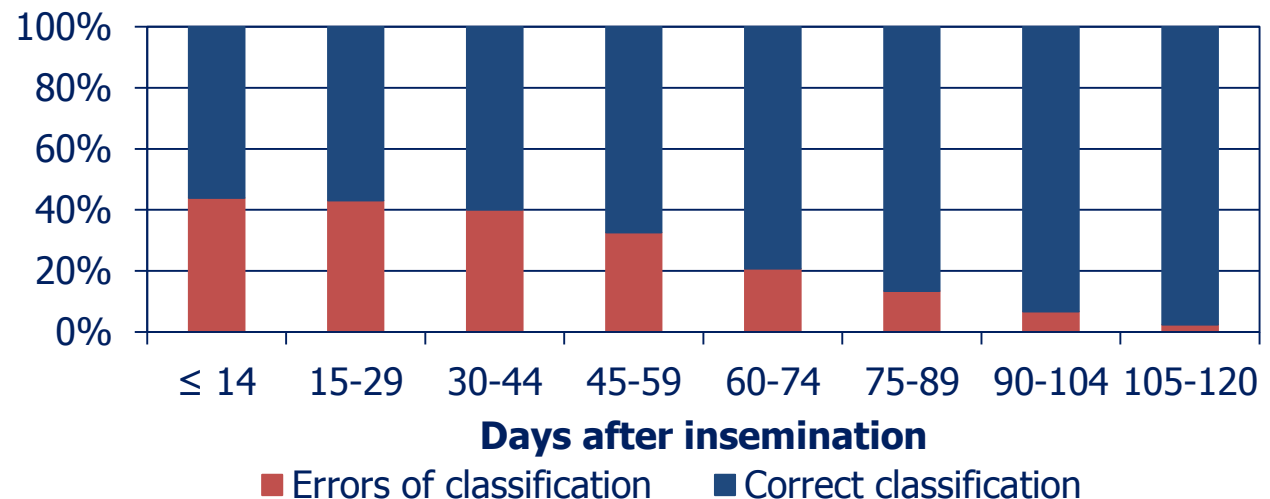
- Average error: 13.1%

# Results

Specificity = 96.8% (NP observations correctly classified)

Sensitivity = 77.0% (P observations correctly classified)

- Average error: **13.1%**
- Classification from validation dataset
  - Distribution by classes of 15 days after insemination
  - Decrease of errors



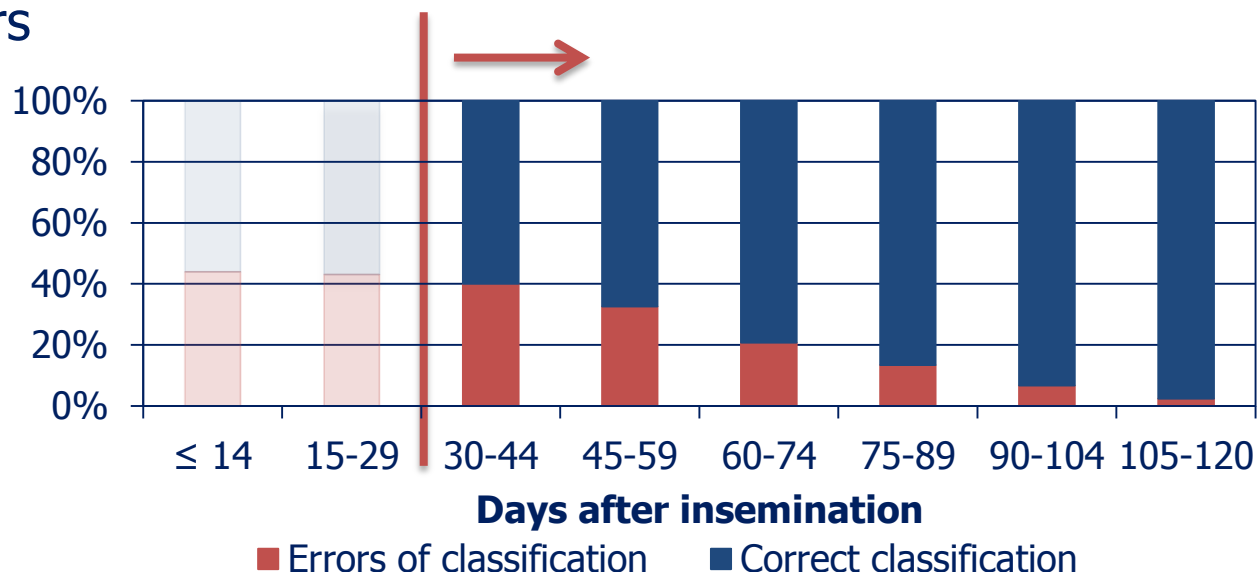
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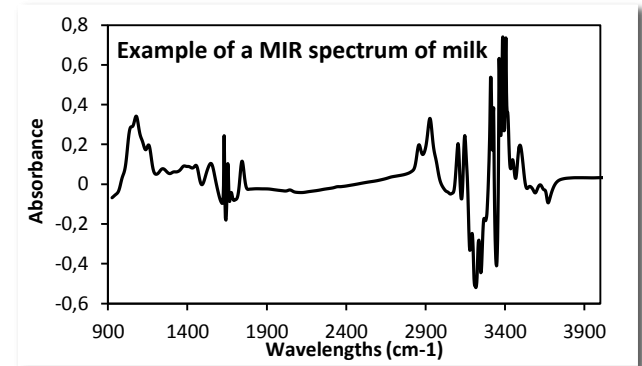
- Average error: 13.1%
- Classification from validation dataset
  - Distribution by classes of 15 days after insemination
  - Decrease of errors

What is the good answer for dairy producers?



# Conclusion

- Direct use of the MIR spectra
  - Cheap
  - Easily transferable
  - MIR spectra already obtained in routine
  - Need an adjustment for other factors



- “ Diagnosis ”
  - Information about a cow status
  - Usefull as a **warning for dairy producers**

# Next steps

- Still under development
  - How are the errors distributed among data?
  - Other options than discriminant function?
  - ...
- Optimisation and validation in the field
  - Test in pilot farms in the Walloon Region
- Development of the tool
  - Milk recording organizations involved in OptiMIR
  - Opportunity to use the same approach for mastitis detection or other metabolic disorders



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