# MODELING AND AUTOMATION FOR PROCESS PRECISION MANAGEMENT

## TESTING OF A SIMPLIFIED OPTICAL SYSTEM FOR RAPID RIPENESS EVALUATION OF WHITE GRAPE (VITIS VINIFERA L.) FOR *FRANCIACORTA* SPARKLING WINE

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Establishing ripeness at harvest is a crucial issue since fruit quality is closely related to it. The search for non-destructive methods which could explore a large number of samples and give a rapid and comprehensive overview of ripening would be helpful. The aim of the research was to design, build and test a prototype of a low-cost and user-friendly device to support small-scale growers in determining the optimal harvest date according to grape ripening degree.

The acquisition of the spectral reflectance at four specific wavelengths (630, 690, 750 and 850 nm) was proposed. Nevertheless, attention was given to the modularity and versatility of the system.

Light emitting diode (LED) technology was chosen as the light source, to achieve the capability to individually adjust the light emission intensity for each measurement channel. A customized optical fiber was specifically designed for the application in order to optimize the radiation transmission.

The prototype was tested for a rapid estimation of ripening parameters of grape for Franciacorta wine directly in field. At the same time, spectral measurements on grape berries were performed (for data comparison) with a commercial portable vis/NIR spectrophotometer operating in the wavelength range of 400-1000 nm, directly in the field too.

A total of 95 bunches of white grapes were collected and non-destructive analyses were carried out on each sample using both the LED based system and the commercial vis/NIR spectrophotometer.

The correlation between the spectral data matrix from the commercial device and the reference parameters (SSC and TA) were carried out.

Finally, a classification analysis was performed.

The percentages of correctly and misclassified grape samples were determined according to ripeness thresholds for the analyzed parameters (ripe > 17 °Brix for SSC and <7 g dm-3 for TA) suggested by the Franciacorta Consortium.

Overall PPV results deriving from the simplified system showed a slightly low classification capabilities (SSC on berry = 79.0%, SSC on bunch = 77.5%, TA = 84.3%) compared to the commercial device (SSC on berry = 84.6%, SSC on bunch = 89.5%, TA = 90.5%).

This means that only a small loss of information was noticeable between the PLS models calculated using 2048 wavelengths and the MLR models calculated employing only the four channels of the simplified device, especially for the TA estimation. Classification performances related to the two optical instrumentations reflect the trend of the quantitative PLS and MLR models confirming the small loss of information using only four wavelengths and, consequently, the applicability of the simplified LED system.

## PRECISION LIVESTOCK FARMING: PROTOTYPING SENSOR-BASED APPLICATIONS

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In livestock production, the monitoring and control of farm environment and animal biological parameters, represent the fundamental part of Precision livestock farming (PLF) techniques. The primary goal of PLF is to develop a farm management system based on the real-time monitoring of these variables. A PLF system is formed by three parts: a physical part, named hardware, which include sensors, actuators and microcontrollers; a part for processing and presentation of data known as software; a part for the communication, called network for transmitting and receiving the information. Mathematical models for data processing and Graphical User Interface (GUI) are included in the software loaded into the microcontroller. The recent miniaturization and reduction of production costs of new technologies can provide researchers with innovative tools to overcome the main constraints of the commercial systems provided for the livestock sector, which are the hardware modularity and its closed source software (commercial software or licensed). Many of current's systems present on the market, in fact, allow to add additional sensors and actuators to the system only if they belong to the same trademark, and also the manufacturers often do not offer a complete assortment of sensors for all the measurable parameters in animal farms.

The aim of the study was to develop two systems using some open source sensors, actuators and micro-controller. The first one is a system for monitoring the rectal temperature of the animals, which is able to send data via Bluetooth to a smart phone. The micro-controller used was an ATmega32U4 (Arduino Pro Micro–5V/16MHz), characterized by: low power consumption, a high performance 8 bit CMOS and low cost. The temperature was read using the LM35 analogic sensor, which can measure in a range from –55°C to 150°C. A Class 1 Bluetooth serial module, which has range of about 100 meter, was connected to Arduino creating a wireless serial link between an Android phone and the Arduino board. The application for receiving data on an android smart phone was created using App Inventor that is an innovative Android application creation software developed by Massachusetts Institute of Technology (MIT). This app is free available on Google Play Store under the name *animal_temp*.

The second system is a prototype for air quality stable monitoring, which is able to detect parameters, such as Particulate Matter, CO, $CO_2$, $NO_2$, $O_3$, $CH_4$, $H_2S$, $NH_3$. The system used a Waspmote which is an open source wireless sensor platform focused on the implementation of low consumption modes to allow the sensor nodes to be completely autonomous and battery powered. The air quality parameters were collected using the Waspmote Gases PRO Sensor Board. The board consists of a robust waterproof enclosure with specific external sockets to connect a sensors, a solar panel for alimentation, an antenna for data transmission and a USB cable in order to reprogram the node.