Innovative platform to develop and establish short supply chains through integration with smart tools for on-tree citrus assessment and dynamic price

Reynaldo Cabezas[1,*], Julia I. Real[2], Polina Batalova[1] and Carlos Baixauli[3]

(1) IDVIA 2020 HORIZONTE 2020 S.L., Plaza de Bandas de Musica 5, Local 11, 46013, Valencia (Spain).
(2) Institute of Multidisciplinary Mathematics, Universitat Politècnica de València, 46022, València (Spain).
(3) Centro de Experiencias de Cajamar, Camino del Cementerio Nuevo, s/n, 46200 Paiporta, Valencia (Spain)

1 Introduction

The most recent Spanish citrus campaign, which began at the end of October 2021, has been catastrophic for farmers, with extremely low prices paid to them, despite a 4.8% reduction in production and a significant upward trend in consumption over the last 20 years, with the 2021/2022 campaign reaching all-time highs globally [1].

Orange is the citrus fruit with the highest production in Spain (accounting for 52.4% of the total citrus crop) with a harvest of around 3.5 million tonnes (73% of which will correspond to the Navel type). Based on agricultural price data published by the *Observatorio de Precios y Mercados* [3], Valencian Navelina oranges have been paid to the farmer at an average price of 0.15 €/kg. However, according to a recent study by the *Instituto Valenciano de Investigaciones Agrarias* (IVIA), the average production costs of citrus fruits in Spain are 0.23 €/kg in the case of oranges (Navelina and Lanelate varieties). These costs could be even higher considering the significant increases that have been occurring for months in costs such as electricity, fertilisers, and water.

These conventional supply chains are rigid and unfair as they are controlled by intermediaries who control prices through massive stockpiling of production, solely on increasing their market share to increase their own profit margins.

The objective of this system is to create a digital platform of citrus products based on Artificial Intelligence that allows the small and medium farmers (1) to assess their crops while still on the tree easily, precisely and at low cost, (2) to receive updated forecasts on the price of their own production in different markets that will allow them to make decisions regarding when and

* Reynaldo Cabezas reynaldo.cabezas@idvia.es

to whom to sell, and finally, (3) once they decide to sell, provide them with information on how to set a dynamic price that guarantees the full sale of their production based on the loss of freshness associated with storage, but prohibiting selling below production costs.

2 Methods

For this to become a reality that would contribute to the generation of a high scientific-technical and international impact of the proposal, the following methodologies must be met:

I) To develop and validate a set of sequential algorithms for the automatic assessment and quantification of the orange crop prior to harvesting using digital images.
II) To develop and validate models for the accurate and continuous prediction of selling prices for a given orange yield in different markets based on global supply and demand estimates.
III) To define and test the design of dynamic pricing strategies for citrus fruits based on the characterization of their freshness loss curve over time.
IV) To develop and validate of a platform prototype in a relevant environment.
V) To define best practices and disseminate the project results to SME farmers, other relevant stakeholders, and public regulatory bodies.

The methodology to be used in the project is diverse, ranging from algorithm programming work, field work to collect data to train and validate the algorithms, and laboratory work with high-precision equipment.

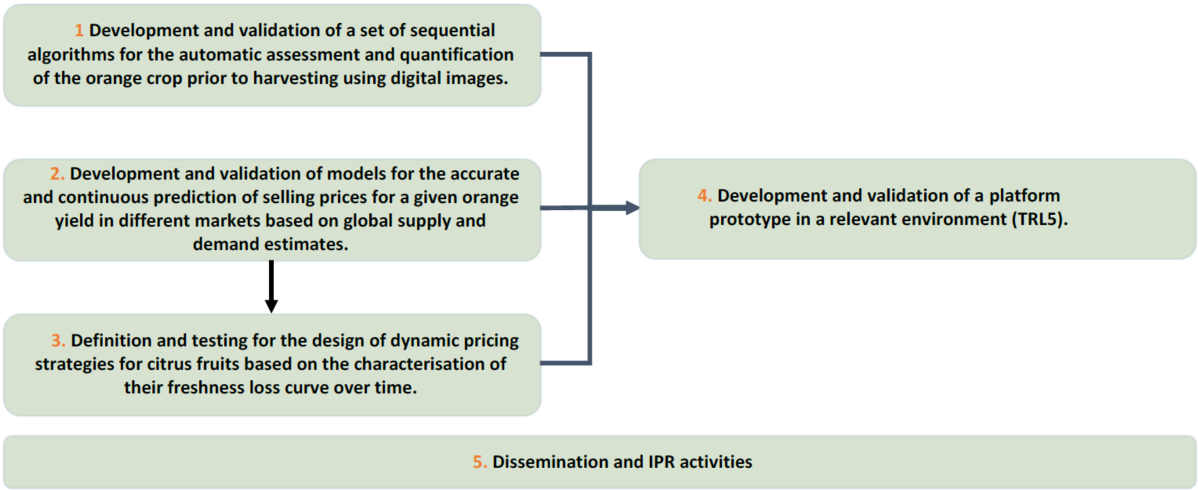

Figure 1. PERT chart.

3 Results

To achieve the objective set, the challenges and innovations carried out to achieve this purpose are detailed below.

3.1 Development and coupling of a set of advanced mathematical image processing algorithms for the rapid and objective assessment of citrus (oranges) production still on the tree using images captured with a conventional digital camera.

It is considered that one of the key aspects of our proposal is to generate a tool that allows the farmer to have the opportunity to preliminarily evaluate his/her production when considered appropriate. This innovation will allow that by taking a picture of a statistically representative sample of trees in the orange orchard, the farmer will be able to obtain an automated and objective assessment of some characteristics.

Below are the key aspects of each of the innovative algorithms that are developed for this:

- I) Advanced Deep learning-based modelling technique for production quantification.
- II) Image processing based on segmentation and binarization (size and shape of the orange).
- III) Image processing based on conversion from RGB color space to standardized color spaces (fruit color index).
- IV) Development of an algorithm for detection and classification of preharvest orange skin defects based on co-occurrence matrix and probabilistic neural networks.

3.2 Highly accurate price forecasts based on different databases and own supply and demand adjusted estimates.

There are many national and international sources of information that provide market information, but they are disaggregated and expressed at different scales, so that it does not allow an overview of an increasingly globalized market.

The challenge inherent in this is that both supply and demand depend on a variety of factors, establishing non-linear or structured relationships between them.

For this reason, it is considered that the best way to meet this challenge is by employing an innovative concept based on adaptive learning neural networks [3]. Thus, the results derived from the estimation of supply and demand will be input into a model based on adaptive learning neural networks to predict prices.

3.3 Dynamic pricing strategy considering the perishable nature of oranges and the necessary logistical optimization.

To achieve a dynamic pricing strategy, it is essential to define a freshness loss function that is coupled with a price evolution model, aspects that must be defined for a non-instantaneous deterioration process of oranges in different storage or preservation scenarios.

Despite being a topic, little explored in the scientific literature, there is a recent theoretical study that proposes that the freshness-time model [4] that allows obtaining a freshness function over time could have the theoretical form shown below.

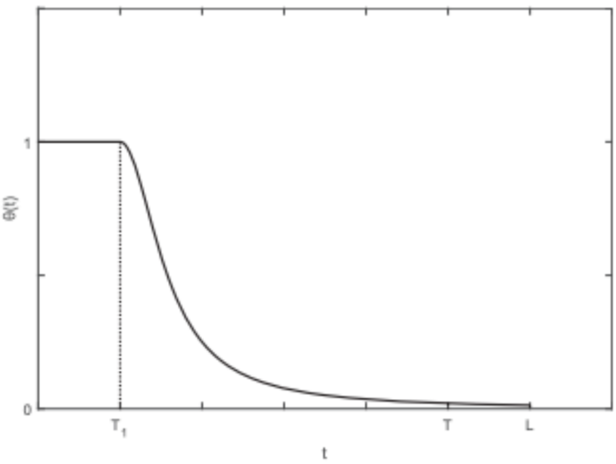

Figure 2. Graphical representation of potential freshness evolution over time for a certain storage condition.

We propose that the oil gland orange characteristics (the rind status) that can be easily quantified as an indicator of freshness [5]. For that reason, its proposed we propose the development of an algorithm based on K-Nearest Neighbors (KNN)-Based Modelling through which to accurately and automatically identify, classify and quantify the different types of oil glands in the orange rinds.

Finally, developing the algorithms of the proposed solution leads to the final result, which is the creation of a digital citrus platform based on the development of artificial intelligence algorithms that allows farmers to achieve the objectives described in the introduction.

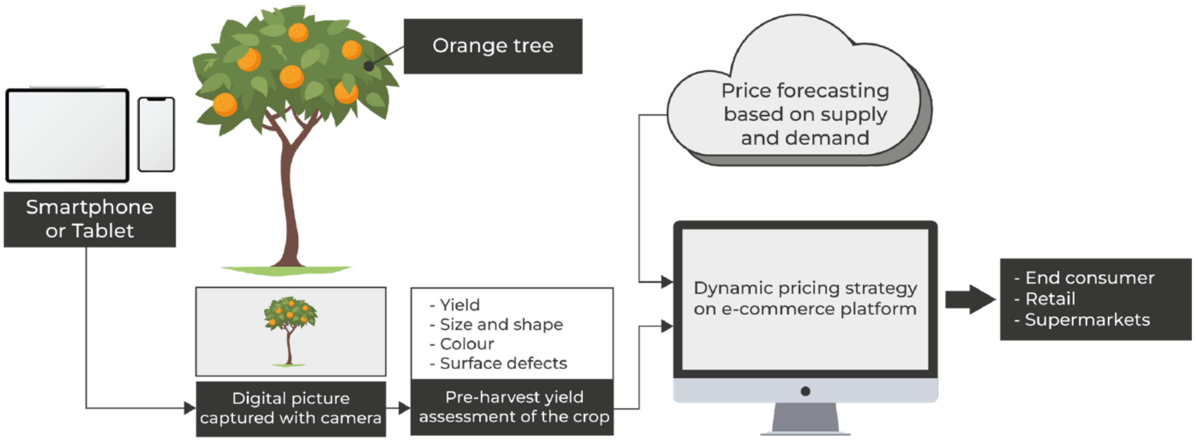

Figure 3. Overview of the solution.

4 Conclusions

In conclusion, by means of such a tool, the farmer will be able to associate virtually with others, which will increase his bargaining power in the short marketing chains that can be established for national and international sales.

In addition to the above, this new and novel system could facilitate the traceability of transactions, making it easier for the Food Information and Control Agency (AICA) - an agency under the Ministry of Agriculture - to investigate and, if necessary, sanction "abusive practices" in citrus purchase and sale contracts that do not even cover production costs.

References

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