# Creation of a gala apple fruit image database for Brazil

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**Abstract**

The development of artificial intelligence systems, especially through techniques such as deep learning, has demonstrated high performance in the analysis and classification of complex data. In the context of fruit growing, the use of image databases has been useful for recognizing patterns of fruit presence in orchards, leading to the construction of models that allow the quantification of production by fruit counting. However, the construction of high-quality databases, containing images associated with physical variables such as weight, height, diameter and visual characteristics (color, texture and shape), is essential to optimize these predictive models. In the case of apples, this information allows the identification of phenotypic patterns, supporting activities such as fruit classification, quality monitoring and improvement of production processes, in addition to improving harvest logistics. However, the construction of an image database, especially aimed at scientific or technological applications, involves several technical, logistical and operational challenges that must be carefully considered to ensure the quality, integrity and applicability of the collection. The objective of the work was to structure a labeled image bank, containing information on diameter, height and weight of the fruits associated with photos of three different faces of fruits, aiming at future obtaining predictive models of productivity for harvesting based on weight and diameter of fruits and not only fruit count.

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**Keywords:** Labeled dataset; Classification; Deep learning.

**1. Introduction**

Apple production is one of the main fruit-growing activities in southern Brazil, with the Maxi Gala cultivar being widely cultivated due to its adaptability and commercial quality. Currently, Santa Catarina and Rio Grande do Sul states are the largest Brazilian producers of apple fruits. The cultivars that have become established in Brazil are clones that belong to the Gala and Fuji groups. The phenotypic characterization of fruits plays an essential role in evaluating the agronomic performance of different cultivation systems and in supporting genetic improvement.

Detailed analyses of the physical and morphological characteristics of the fruits become indispensable for understanding the behavior and adequate management of the cultivar in different environments and management conditions. However, there is currently a lack of image databases with apple fruits characteristic of Brazil, and their construction and availability are necessary for advances in the area of computer vision applied to production monitoring and predictability (Pereira, 2021). Therefore, the standardization of assessments, combined with the use of technologies such as professional cameras and digital measurement tools, contributes to the generation of reliable and comparable data between studies.

The development of predictive models of fruits for harvesting has been a major advance in the use of computer vision and deep learning models, but they are restricted to counting fruits or, when they are highlighted on the plant, to the creation of a geometric figure with a known radius that counts the fruit as a unit (Hauagge, 2008). The integration of morphometric data with digital images allows the accurate estimation of physical parameters of fruits, optimizing harvest planning and storage logistics (Gottschall et al., 2018).

The present research aimed to create an image database by documenting phenotypic characteristics of fruits of the Maxi Gala cultivar, originating from two different orchards. By systematically collecting and organizing physical data (weight, height and width of fruits) and images, we aim to provide a solid basis for future studies, including applications in pattern recognition using computer vision and artificial intelligence techniques. The approach adopted reinforces the importance of integrating traditional analysis methods with technological innovations, expanding the scope and accuracy of assessments in temperate fruit growing.

**2. Methods**

The study is based on fruits obtained from two orchards of the Maxi Gala cultivar, planted in September 2011, named “Fitotecnia” and “Gerenciamento”, at the Temperate Climate Fruit Experimental Station of Embrapa Uva e Vinho, in Vacaria–RS (one of the ten Agrotechnological Districts of the Semear Digital Project (Semear Digital, 2025)). Data collection was conducted on a sample set of 92 plants distributed in a regular grid, aiming to ensure the representativeness of phenotypic variability. All fruits present on each of the plants were harvested manually at the physiological maturity stage, identified based on visual criteria and technical parameters, on February 11, 2025. After harvest, the fruits were stored in perforated polyethylene bags duly identified with the code of each plant of origin. The samples were stored under controlled refrigeration conditions, at a temperature of +0.4°C, until the time of the evaluations and photographic records.

Evaluations took place between February and April. Initially, the fruits were numbered individually and subjected to height and diameter measurement with an Insize digital caliper. Subsequently, each apple was weighed individually using a Shimadzu precision scale. Data collection was performed manually, with records in physical format (sheets of paper) that are later digitized into .XLSX files, using OCR (Optical Character Recognition) technology with the support of artificial intelligence technologies, in order to feed the labeled dataset, to be constructed in SQL language, the final product of this work, as suggested in Memon et al. (2020).

For the photographic record, the fruits were arranged at a regular distance of 50 cm from the camera lens, with a white background. Each fruit was photographed from three different angles, aiming to capture relevant morphological characteristics. The equipment used was a professional Cannon camera, calibrated to ensure uniformity in image resolution and quality. Special care was taken with the resolution and pixelation of the images, which is a critical aspect for artificial intelligence applications, since low-resolution or excessively pixelated images can compromise the ability of algorithms to recognize subtle patterns.

For future tests to validate the database, a Yolo V5 neural network will be used in simulated applications, seeking to analyze the images and correctly identify their dimensions and correlate them with weight. In order to obtain a more accurate result, the information in the table will be related to the images and the neural network will be trained with a sample of at least 2,000 lines from the database. (Terven et al., 2023).

**3. Results and Discussion**

The data obtained from the laboratory work, recorded manually in a text table, and later converted to a table in an .XLSX file that will be converted into the database as a dataset labeled in SQL language, is being ordered in each line with the information recorded in the following manner: fruit number, orchard from which it was extracted, plant number, fruit diameter measured in millimeters (mm), fruit height measured in millimeters (mm), weight measured in grams (g) and three more columns containing links to address the images captured from three different angles of each fruit (Figure 1).


**Figure 1.** Necessary steps and scheme for creating an image bank of Gala apple fruits in Brazil. Column 1 - Fruit number; Columns 2 and 3 - identification of the orchard and the number of the sample tree; Columns 4 and 5 - Diameter and height of the fruit ($mm^{-1}$); Column 6 - Weight ($g^{-1}$); Columns 7, 8 and 9 - Photos of different faces of the fruit, always taking one of them with the greatest height and the greatest diameter.
**Photos**: Luciano Gebler.

To create this database, more than 21,000 photos were taken, with each set of 3 images making up a row of the database, resulting in approximately 7,000 entries. Once this stage is complete, the database will be tested for resilience and robustness, verifying the consistency in the extraction of information. It was decided to use an application with YOLO V5, given its worldwide use and recognition in working with images (Terven et al., 2023), carrying out tests with samples. The objective will be to correlate the area of the fruits with weight and volume, allowing more accurate assessments at harvest time and more detailed planning in the logistics of use and movement of bins and in the allocation of people. Once the success of the application is confirmed, the database is expected to be made available for use by the Semear Digital project (Semear Digital, 2025), in order to produce new applications, mainly related to harvest logistics and advances in computer vision of agricultural machinery.

## 4. Conclusion

Creation of a database of labeled images associated with phenotypic information on fruits of the Maxi Gala cultivar represents a significant advance in the development of solutions based on artificial intelligence in temperate fruit growing. By bringing together high-quality images and physical data such as fruit weight, height and diameter, the study will provide a robust basis for training and validating predictive models such as deep learning, capable of making more accurate productivity estimates, overcoming the limitations of traditional methods, based solely on visual counting, in addition to potential new technological tools aimed at the efficient management of agricultural production.

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## References

GOTTSCHALL, C. R. de A.; LIMA, D. S.; MARQUES, J. E. S.; AMADO, J. A. D.; LIBARINO, C. S. Seleção de qualidade de frutas do tipo manga utilizando visão computacional com redes neurais aplicada a um processo de manufatura robotizada. In: MOSTRA NACIONAL DE ROBÓTICA (MNR 2018), 2018, João Pessoa. **Anais** [...]. [João Pessoa]: NMR, 2018. p. 715-721. Editores: Alexandre da Silva Simões, Esther Luna Colombini, Flavio Tonidandel. Available at: https://mnr.robocup.org.br/wp-content/uploads/2021/08/MNR-Anais2018_V2-FINAL-1.pdf. Accessed on: Apr. 24, 2025.

HAUAGGE, D. C. **Aplicação de algoritmos de visão computacional à inspeção industrial de maçãs.** 2008. 94 p. Dissertação (Mestrado em Ciência da Computação) – Instituto de Computação, Universidade Estadual de Campinas, Campinas. Available at: https://www.cs.cornell.edu/~hauagge/files/pdf/hauagge_msc.pdf. Accessed on: Apr. 24, 2025.

MEMON, J.; SAMI, M.; KHAN, R. A.; UDDIN, M. Optical Character Recognition (OCR): a comprehensive Systematic Literature Review (SLR). **IEEE Access**, v. 8, p. 142642-142668, 2020. DOI: https://doi.org/10.1109/ACCESS.2020.3012542.

PEREIRA, J. K. O. **Uso de visão computacional para reconhecimento de imagens de frutas em imagens RGB.** 2021. 33 p. Monografia (Bacharelado em Ciência da Computação) - Universidade Federal do Ceará, Russas. Available at: https://repositorio.ufc.br/bitstream/riufc/64490/1/2022_tcc_jkopereira.pdf. Accessed on: Apr. 28, 2025.

SEMEAR DIGITAL. **O Centro de Ciências para o Desenvolvimento em Agricultura Digital.** Available at: https://www.semear-digital.cnptia.embrapa.br/. Accessed on: Apr. 24, 2025.

TERVEN, J.; CÓRDOVA-ESPARZA, D. M.; ROMERO-GONZÁLEZ, J.A. A comprehensive review of YOLO architectures in computer vision: from YOLOv1 to YOLOv8 and YOLO-NAS. **Machine Learning & Knowledge Extraction**, v. 5, n. 4, p. 1680-1716, Dec. 2023. DOI: https://doi.org/10.3390/make5040083.

# Integration of the SAR and optical sensors of the Sentinel constellation for land use classification in Lagoinha (SP)

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**Abstract**

Information on land use and coverage is necessary to assist in the management process and assertive decision-making. Thus, the present study aimed to evaluate the fusion of Sentinel-1 (S1) and Sentinel-2 (S2) data in the mapping of land use and coverage of the municipality of Lagoinha (SP) using the Random Forest method. Three scenarios were tested for classification: data from (S1), (S2) and fusion of (S2+S1). To evaluate the accuracy of the classification, high-resolution images from Google Earth and S2 software were used. The overall accuracy of the classification from the combination of S2+S1 data was 94%, and the Kappa index was equal to 0.9. For the isolated images of S2 and S1, overall accuracies of 80% and 50% and Kappas index of 0.71 and 0.50 were obtained, respectively. The fusion of S1+S2 data showed high accuracy in mapping.

**Key words:** Remote Sensing; Sensor Fusion; Radar; Machine Learning; Land Use.

## 1. Introduction

The Sentinel-1 (S1) and Sentinel-2 (S2) satellites, launched by the European Space Agency (ESA), have improved the way in which land use and land cover monitoring and classifications are carried out (Gómez, 2017). Sentinel-1 has an active SAR (Synthetic Aperture Radar) sensor, which is useful for monitoring areas of dense vegetation in adverse weather conditions (Tavares et al., 2019). Sentinel-2 is equipped with a passive optical sensor with 13 multispectral bands, which performs planned analyses of vegetation types and their phenological and physiological conditions (Gava et al., 2024). Several studies have shown that the fusion of multispectral images from S2 with the

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