RESEARCH ARTICLE

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Development of Apple MRI Dataset for Internal Quality Analysis

Vidya D[1], Shivanand Rumma[2], Mallikarjun Hangarge[3]

[1]Department Computer Science, Govt Woman's First Grade College, Kalaburagi, Karnataka, India

[2]Department of Computer Science, Gulbarga University, Kalaburagi Karnataka, India

[3]Department of Computer Science, Karnataka Arts, Science and Commerce College, Bidar, Karnataka, India

Abstract

Internal quality assessment of agricultural products is challenging for exporting premium quality of Agri products like apple fruits. In this, we have analyzed the internal quality of apple fruits by a non-destructive method. We have developed our own dataset of MR images of apples by subjecting 21 apples into MRI scanning for the development of robotics detection of internal defects in apples. This MRI scanning led into 196 MR images Comparative study was carried out on the basis of MRI images with respective external photographic images of apple fruits. The apples were grouped into four categories depending on external and internal defects. By this study, we can easily identify the percentage and area of the defect without affecting the physical appearance of the apple.

Keywords: MRI images, Non-destructive, dataset, robotics.

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Introduction

Agriculture plays a crucial role in improving developing countries' economic conditions, whereas maintaining quality parameters in agricultural products becomes a big requirement in the global market. Maintaining the quality of plant products is a big challenge because there are environmental stress factors and pathological invasion. There are several ways to detect the internal structure of agricultural products.

Apple fruit is a highly consumable fruit all around the world that holds high commercial value. There is always a challenging aspect in the quality analysis of apple fruits. Apple fruit has few internal diseases that cannot identify by physical observation. (Komal Sindhi *et al.,* 2016).[1] Different non-destructive technologies are available to detect internal defects on agricultural products and the advantages and disadvantages of using different technologies like X-rᵃy, NIR, Sonic/ Ultrasonic method, and MRI on Mangoes fruit diseases (Anita Raghavendra *et al.*, 2016).[2]

Modern challenges in food science require an understanding of the new determinants of the quality and safety of food products. MRI has seen fast growth over the past decades, and MRI allows the structure of food to be imaged non-destructively Since MRI is considered a safety scanning technique. It does not have any harmful radiation, it can be considered as a magnificent tool for the quality control of food products (Ebrahimnejad Hamed *et al.*, 2018).[3]

Cheng-Jin Du and Da-Wen Sun (2004)[4] reviewed new advances in image processing techniques for the quality evaluation of food products. Ebrahimnejad Hamed *et al.* (2018) [3] reviewed the use of magnetic resonance imaging (MRI) in food quality control. The author observed that MRI allows the structure of agricultural products to be imaged non-invasively & non-destructively. This review provides an overview of the most appropriate applications of MRI in agriculture.

Krishna Kumar Patel *et al.,* (2015)[5] reviewed recent improvements in the application of the MRI method for food and agriculture products. MRI scanning is a significant technology to get different variety of measurements for the evaluation of growth and quality factors in different agricultural products and other food materials but also to improve the understanding of fundamental physiological parameters.

Boan Zion *et al.*, (1995)[6] proposed the use of MRI to detect bruises in apples. The author used various pulse sequence techniques to investigate temporal changes in MRI image contrast in affected & healthy areas of flesh. The author also reported that with time contrast between bruisedand non-bruised regions was found in the increasing trend.

Corresponding Author: Vidya D, Department Computer Science, Govt Woman's First Grade College, Kalaburagi, Karnataka, India, e-mail: vidyasarvottam80@gmail.com,

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Thijs Defraeye T *et al.* (2013)[7] proposed an application of MRI for Braeburn apple's tissue analysis. This study investigated small samples of Braeburn apples with field MRI to identify major differences in tissue types. The author focused on MRI images for tissue characterization concerning inner and outer cortex tissue and produced internal quality defects such as voids, damages due to worms, or bruising & their variation over time.

Magnetic Resonance Imaging (MRI) is a more improved imaging method used to produce high-quality images of agricultural products. There are several technologies used for classifying MR images, which are " fuzzy methods, neural networks, knowledge-based techniques, shape methods, variation segmentation," etc. (Murugavalli 2006).[8]

The present study is carried out on documentation of the new apple MRI data set and comparisonbetween MRI images of apples with photographic images of those respective fruits.

Materials And Methods

23 Delicia apples were brought from the local market. Based on morphological appearance, apples were categorized into two groups as good (G) and defect (D). Four apples were in good condition, and the remaining nineteen had some morphological defect. Based on the morphological appearances, all apples were labeled and then color photographic images of each apple were taken at different angles like Front, Back, Arial, and Bottom (Figure 1). then these individual Apples were subjected to vertical and horizontal MRI scanning (Figures 2 & 3). MR images were obtained using 1.5 Tesla Sieman's Magnetom Spectro MR machine with T2- weighted MR images with a repetition time (TR) of 8980 and Spin echo time (TE, the period during which sample magnetization dephases and then rephrases) of 100.2 with slice diameter of 116.7mm and interslice gap of 8.0mm. The total number of slices for all channels ranges from 9 to 33, leading to 145 images. The pixel size of each image was 512 X 512 (Table 1). The images are grayscale. MR image generation time depends on the resolution. The higher the desired resolution the more acquisition are adopted for image generation and the longer it takes to acquire an image. MRI images were analyzed using RadiAnt DICOM Viewer (64-bit) software. After, documenting NMR images all the individual Apples were cut vertically and made into two halves with knife and color photographic images were taken for internal

Figure 1: Apple photography in different directions. (F: Front, BK: Back, A: Arial, BT: Bottom)

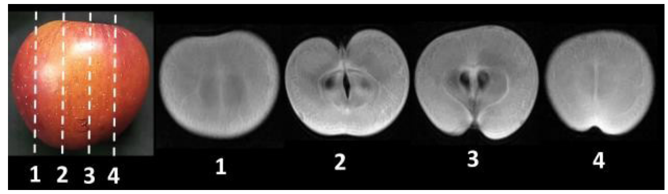

Figure 2: Apple's vertical slices of MRI images.

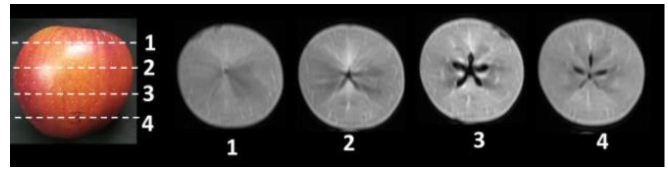

Figure 3: Apple's horizontal slices of MRI images.

Table 1: Experimental characteristics of MRI measurements.

Method	Values
Machine	1.5 Tesla Sieman's Magnetom Spectro
TR	8980
TE	100.2
Slice diameter	100.2
Slice gap	8.0 mm
Image size	512 x 512

appearances. Visual inspection of the internal structure, locations and severity of the defects was made. Finally, each apple's color photographic images were aligned with respective apple MRI images, and a comparison study was carried out.

Results And Discussion

Only 21 apple fruits were able to scan and a total of 196 MRI slices were acquired by RadiAnt DICOM Viewer (64-bit) software. Most of the individual apple has ten MRI images out of whichfive vertical slices and five are horizontal. Only a few individual apples have less than five verticalslices. After aligning photographic as well as vertical and Horizontal MRI images, a detailed defect observation chart has been prepared (Table 2).

Table 2 shows fruits were categorized into four groups (Table 3). Group 1 has fruits that are seen as healthy and no defect are observed externally and internally. Fruits G1, G4 fall under this group (Figure 4). Group 2 has apple fruits (G2 & G3) that were externally healthy. In contrast, the internal vertical cut apple part and MRI images have a slight defect in the peripheral region of apple fruits (Figure 5). Group 3 has fruits (D3, D5) with external defects. In contrast, MRI images has no defect observed (Figure 6). Group 4 is made on the following criteria where apple fruits have defect externally as well as internally when comparedwith photographic as well as MRI images (D1, D4, D6, D7, D9, D10, D11, D12, D13, D14, & D15) (Figure 7). These apple MRI images indicate the

Table 2: Defected history (H: Horizontal section, V: Vertical Section, N: No defect, Y: Defect).

Sl. No	Apple No.	Photographic image		Apples MRI images Showing Internal Defect									
		Uncut Apple	Vertically cut apple	Slice 1		Slice 2		Slice 3		Slice 4		Slice 5	
				H	V	H	V	H	V	H	V	H	V
1	G1	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”
2	G2	“N“	“Y”	“N”	“N”	“Y”	“Y”	“N”	“Y”	“N”	“Y”	“N”	“N”
3	G3	“N“	“Y”	“N”	“N”	“N”	“N”	“N”	“N”	“Y”	“N”	“N”	“N”
4	G4	“N“	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”
5	D1	“Y”	“N”	“Y”	“Y”	“Y”	“Y”	“Y”	“N”	“N”	“N”	“N”	“N”
6	D2	“Y”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”
7	D3	“Y”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”
8	D4	“Y”	“Y”	“Y”	“N”	“Y”	“N”	“Y”	“N”	“Y”	“N”	“N”	“N”
9	D5	“Y”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”
10	D6	“Y”	“Y”	“Y”	“Y”	“N”	“Y”	“N”	“Y”	“Y”	“N”	“N”	“N”
11	D7	“Y”	“Y”	“N”	“N”	“Y”	“N”	“N”	“N”	“N”	“N”	“Y”	“N”
12	D8	“Y”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”	“N”
13	D9	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“N”	“N”	
14	D10	“Y”	“N”	“Y”	“Y”	“Y”	“Y”	“N”	“Y”	“Y”	“Y”	“N”	
15	D11	“Y”	“Y”	“N”	“Y”	“N”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”
16	D12	“Y”	“Y”	“Y”	“Y”	“N”	“Y”	“N”	“Y”	“Y”	“Y”	“N”	“Y”
17	D13	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“N”	“Y”		“Y”	
18	D14	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”	“Y”		“N”	
19	D15	“Y”	“Y”	“N”	“N”	“N”	“Y”	“N”	“Y”	“Y”		“Y”	
20	D16	“Y”	“N”	“N”	“N”	“N”	“N”	“N”		“N”		“N”	
21	D17	“Y”	“N”	“N”	“N”	“N”	“N”	“N”		“N”		“N”	

Table 3: Grouping of Apples by comparison study between MRI and Photographic pictures of individual apples.

S. No.	Group No.	Grouping Criteria	Apple No.
1	Group 1	No External & Internal Defect	G1 & G4
2	Group 2	No External defect but Internal defect	G2 & G3
3	Group 3	Defect at Externally but No defect Internally.	D2, D3, D5, D8, D16 & D17
4	Group 4	Defect at Externally & Internally.	D1, D4, D6, D7,D9, D10, D11, D12, D13, D14, & D15

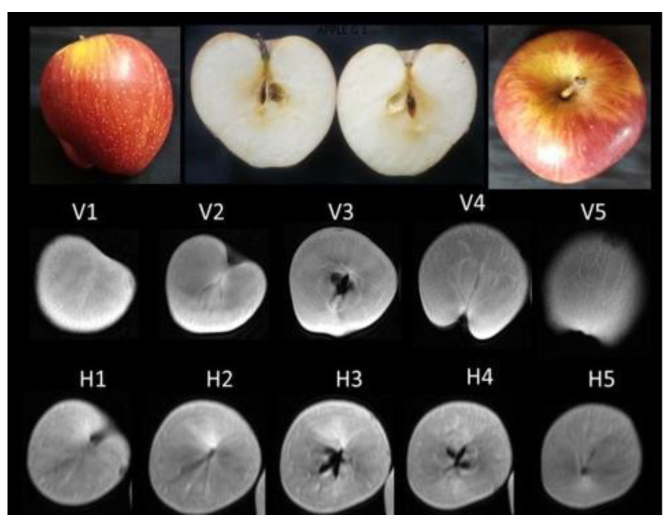

Figure 4: Group 1 representative (G1), external pictures aligned with 1 to 5 Vertical & Horizontal MRI images

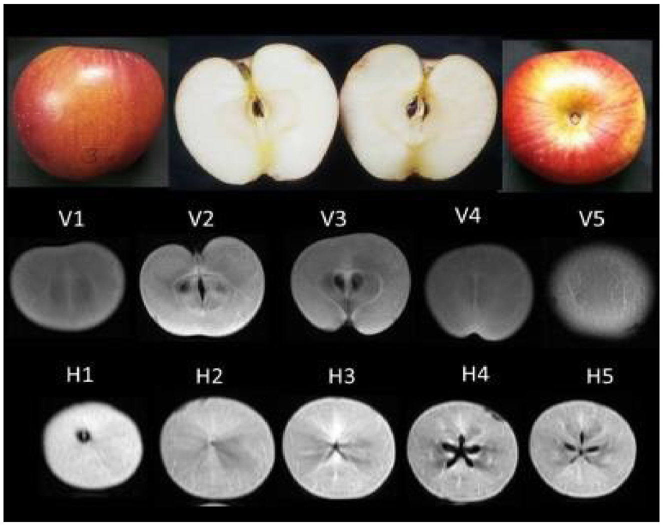

Figure 5: Group 2 representative (G3), external pictures aligned with 1 to 5 Vertical & Horizontal MRI images

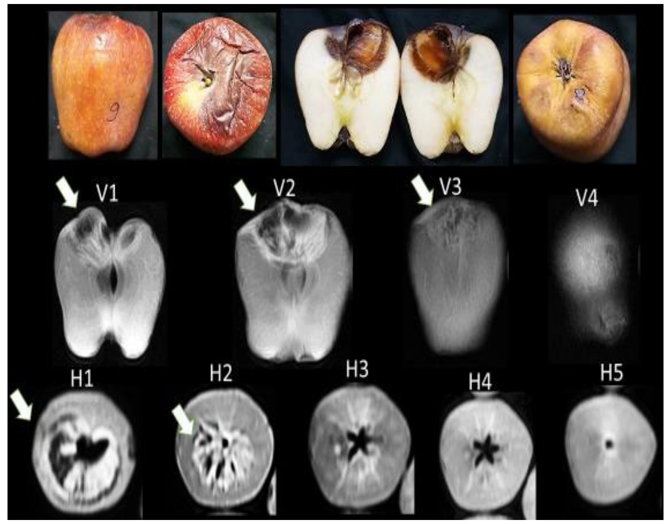

Figure 8: D9 Apple's external pictures aligned with 4 Vertical & 5 Horizontal MRI images.

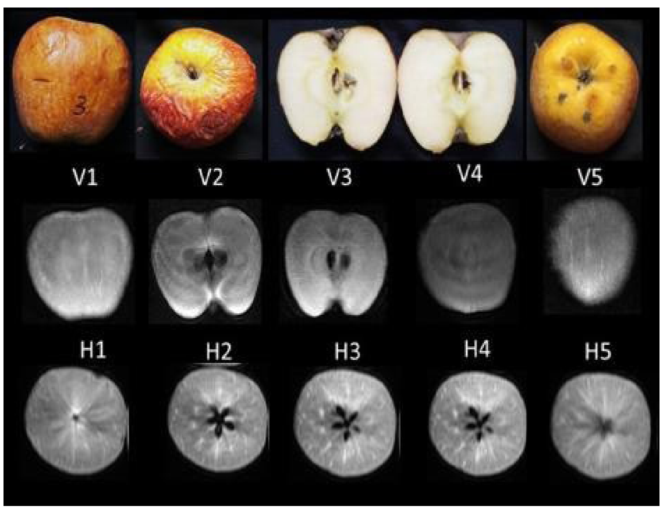

Figure 6: Group 3 representative (D3), external pictures aligned with 1 to 5 Vertical & Horizontal MRI images

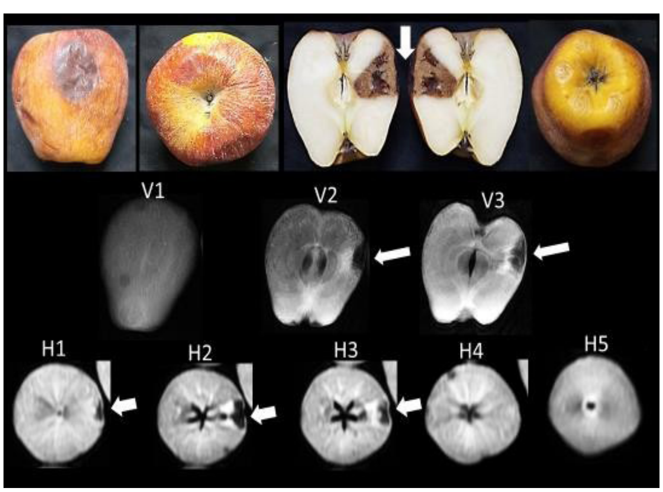

Figure 7: Group 4 representative (D14), external pictures aligned with 3 Vertical & 5 Horizontal MRI images.

location and severity of the defect. For example, in Apple D11, the first two horizontal slices of MRI images do not have any defects, but when we move further, three slices had a clear-cut defect area because that fruit was having defects only at the bottom side of that fruit. Whereas in Apple D9, the first two horizontal slices of MRI images had a prominent defect, but other slices 3,4, and 5 were not showing any defects (Figure 8). This indicates that fruit has defects at the top layer but not in the bottom layers of that particular apple fruit. Defect severity is also calculated based on the coverage area of the defect and color intensity in the MRI images.

Conclusion

This study of the internal quality assessment of Apple indicates that MRI is a non-destructive and non-invasive technique. This entire study was carried out manually to determine the internal quality of 21 Apples, giving 196 images of different slices. This becomes a very difficult and tedious process for a larger number of Apple's screenings. Further study must be carried out to simplify the internal quality of any fruits using Digital Image Processing Technology.

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