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Automated Inspection and Grading of Vegetables Using Multisorting System Based on Embedded Platform

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Abstract: ***Food is essential for nourishment and sustenance of life. The food sorting system gives us various information like color, shape, size, defect etc. There are two way for inspecting food products, first is the external food inspection while other is the internal food inspection. External inspection is done through image processing while internal measurement is done by sensors which can calculate moisture content, sugar content etc. In this paper embedded system is designed for multisorting and it is implemented through Matlab. It is a user dependent system, where user has to decide what type of sorting is required whether it's on basis of color, size or quality. Manual method is slow, costly and also lacks reliability and objectivity required in competitive food industries. The system consist of one web camera, personal computer, two servomotors, one PCB, microcontroller working on Arduino platform, one LCD for displaying on which mode are you working and other mechanical part. The samples of different vegetables are situated in front of camera and are calibrated off line. All the information are extracted and saved in database.***

Keywords: **M**achine vision, Image processing, multisorting, embedded, vegetable.

1. Introduction

By giving a vision to computer, its application has extended in various field where significant information is extracted automatically from images and it has also provided necessary theory and example for a practitioner in field of multimedia, art and design, geographic information system, image database, medical imaging, remote sensing, computer cartography, autonomous vehicles and robot sensing [1]. With advancement of methodologies in machine vision human endeavor is replaced by automatically perceived image which are obtained by combination of physical image sensor, dedicated hardware and software instruments [2]. For providing consistency in product quality and to handle large varieties of vegetables and fruits automation via computer vision is required. The United States of Department of Agriculture (USDA) has classified five grades of potatoes. The attributes for deciding these grades are size, shape, external defect. The system correctly classified 80%, 77% and 88% of moving potatoes in three runs at 3 potatoes per minute and 98%, 97%, 97% in three run of stationary potatoes [8]. With the help of capability of computer vision in food industry, this industry is now ranked among the top 10 industries. Many vision based system has been designed for different food products automated inspection such as tomato, dates, oranges, potatoes, bakery products, aquatic foods, grains and many other products [3][7][4][8][5][6]. One of the important parameter is freshness of fish, which can be calculated using techniques of machine vision. Here a digital color imaging system was applied to provide accurate CIELAB color measurement of eyes and gills [6]. An automatic and intelligent system has been developed by S. Nashal, A. Abdullah, S. Armvith, M. Z. Abdullan [2011] for classification of biscuit products according to their color. Here biscuits are classified in 4 groups basically under baked, moderately baked, over baked, considerably over baked based on two analysis support vector machine (SVM) and wilk's λ analysis [5].

In this research, an embedded system based on Matlab is developed for multisorting purpose based on color, size and quality for vegetables. Here we have tested the system for tomatoes and capsicum however the system can be applied for other vegetables, but for that special training as well as efficient calibration is required. This paper is organized in four parts, in first part all the hardware component, software part, and their working have been described, second one is the hardware testing part third one is the material and method for computer vision and matlab working part and last one is the result and analysis.

2. Hardware components and software used

2.1 Embedded System Hardware

Embedded Systems are components integrating software and hardware jointly and specifically designed to provide given functionalities. A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function. In some cases, embedded systems are part of a larger system or product, as in the case of an antilock braking system in a car. Such equipment is electrical or battery powered. The chip controls one or more functions of the equipment, such as remembering how long it has-been since the device last received maintenance. An Embedded System is a special-purpose computer system designed to perform one or a few dedicated functions, often with real-time computing constraints. In our work embedded hardware is dedicated to rotate servomotor toward specific bin based on what type of

input is obtained after image processing via matlab. All related hardware is shown in figure1.

2.2 Hardware Elements

2.2.1 Processing block: AVR family atmega 168,it's a 28 pin ic,16kb flash memory,8 bit processor, 14 digital IP/OP port, 6 analog IP/OP port, 16 MHz clock frequency, 1 UART,

2.2.2 Basic circuit elements: power source, clock, reset, timers, memory, glue circuit for the elements linking and interfaces

2.2.3 Keypad, LCD display matrix or touch screen

2.2.4 IO communication elements: buses (serial and parallel), interfaces for network interface, ADC, DAC, pulse dialer, modem, Bluetooth, 802.11, as per the application

2.2.5 Interrupt Handler

2.2.6 Output block: servomotors are used for sorting. They give accurate angle movement, it receives pwm signal. It can move total 180 degree. From the base position it can move either -90 or +90 degree.

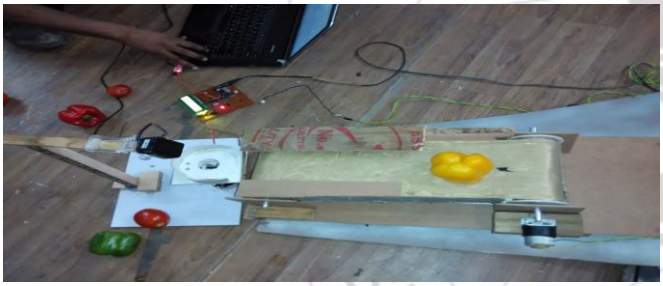


Figure 1: Embedded multisorting hardware

Embedded system hardware basically consists of three main elements:
Input System: Input system is the basically used to interact with external environment or type of input the user want to give. There can be various type of the input system depending upon the user or system need. Some of the examples are sensor interfaces (IR, LDR etc.), UART interface (for communication with PC), Wireless interfaces for various type of wireless communication etc. These interfaces have also a good circuit design and should be properly designed so that it can easily interact with the next unit.

Processing Unit: The next unit is the processing unit that consist either analog circuit to process the input or to make the system perform good and user dependant (as per program) uses the microcontroller interface circuit. The main function of this unit is to take the input, process it and generate the desired output as per the program (done by user) to control the output unit.
Output unit: The output unit consists of the circuit interface to generate and control the desired output. For example the relay driving unit, motor driver unit, alarm systems, Display units etc.

2.3 Software and library used

Software used
Arduino compiler……controller program
Dock light…… hardware manual testing
cp2102…….. USB to UART driver

Library used:
Servo.h
LiquidCrystal.h

Sorting Component:
Two axis servo mechanisms are designed.
There is simple conveyor arrangement to place the object on sorting mechanism.

Interfacing:
SERVO base---D8 of uC, Servo arm---D9 ofuC
16x2 LCD -----D2,D3,D4,D5.D6,D7
RX-TX UART MODULE----D0,D1 of uC.

2.4 Hardware Working

The +12V DC power is fed to the board. Arduino compiler has been used using c, c++. Arduino compiler is easily available, also all its library is free. Only thing which we have to buy is its burning board. Process of transferring code from personal computer to microcontroller is called burning process. The controller checks the acknowledgment from the MATLAB interface designed to check the various food products on the basis of color, size and feature analysis. The acknowledgement sent is the ASCII characters 1 2 3 on the basis various detection. The USB to UART module is used to make the controller compatible with PC. The means of communication is UART. The ASCII characters are received by the controller. The controller is programmed in Arduino to check the received characters and give the signal to the servo motor to move for different position and place the object. Two axis servo mechanisms are designed. There is simple conveyor arrangement to place the object on sorting mechanism.

3. Hardware Testing

1. Connect the black terminal of the Digital Multimeter to the ground of the supply source and turn the knob to 20V DC voltage.
2. Make sure the notch of all the IC's including microcontroller is correct.
3. Check the continuity and short circuit of the PCB's.
4. Provide supply of 12V to motor driver board from main board
5. Check the voltages at pin o (output) of both 7805 and it should be +5 volts on the boards
6. Check the voltage at pin 7 and 20 of the microcontroller it should be +5 volts.
7. Check the voltage at pin 2 and pin 15 of the LCD, It should be +5V

8. LCD should display all these data.
9. If all the above parameters are met, then the testing part is complete and we can run our Project.

Caution: Check the orientation of LCD and all IC.

Hardware testing using DOCKLIGHT
1. Install dock light and CP2102 driver
2. Power the board +12V DC
3. Insert the module in PC USB
4. Right click on the My computer---Manage-----Device manger-----Ports& COMS
5. Check the COM name for Silicon Labs CP210
6. Open the dock light .Double click on COM icon on uppermost right side.
7. Select the same Com as in step 5 from drop down menu
8. Drop Set the baudrate 9600 from the drop down menu and finally apply

4. Material and method

4.1 Machine Vision System

Computer vision system consists of five basic elements camera, optics, illumination, and Image acquisition hardware and machine vision software. Mostly solid state cameras are used in machine vision applications. Type of solid state camera used are 1.CCD (camera coupled device), 2. CID (charge injected device) and 3. CPD (charge priming device). CCD, CID, CPD are compared in Galbiati[5]. Illumination : Illumination technique consideration include whether the object is dull or reflective, flat or complex in shape, if through holes are to be deflected or to find if there is surface defect. Five categories of lighting can be distinguished for machine vision 1.Front lighting, 2.Back Lighting, 3.Side lighting, 4.Structured lighting, 5.Strobe lighting. They are classified on the basis of position of light source relative to the camera. Lighting technologies include incandescent lamps, sodium vapor lamp and lasers.
Machine vision stages are image acquisition, image processing, image enhancement, image restoration, image segmentation, image analysis, model matching. Stages of machine vision are shown in figure 2.

4.2 Matlab implementation in Machine Vision System

4.2.1 The basic steps are

1 Image acquisition
An image of vegetable is captured by using a webcamera by using matlab function ‘getsnapshot’. If the image is grayscale image than it is stored as MXN array. Else if its colored image or RGB image than it is stored as an MXNX3 array. The syntax for getting an image is
vid = videoinput ('winvideo', 2, 'YUY2_640x480');
data = getsnapshot(vid);
2 Than the serial communication by UART has been acknowledged at the rate of 9600 baud rate.
ser=serial ('COM1','Baudrate',9600);

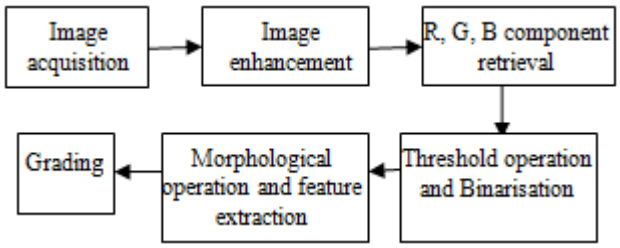


Figure 2: Stages of machine vision

3. Extracting RGB data
First RGB image is converted to grayscale image by eliminating the hue and saturation information while retaining the luminance by syntax”rgb2gyay”.If the image is gray scaled image than from the grayscale image it’s required to extract the red, green and blue components in the image by following syntax
R = imsubtract(data(:,:,1), rgb2gray(data));
G = imsubtract(data(:,:,2), rgb2gray(data));
B= imsubtract (data (:,:,3), rgb2gray(data));
Here since we have taken red, green and yellow capsicum for our experiment, so extraction of yellow color is also required, for that we have taken the snapshot of yellow colored capsicum and in its matlab image via use of data curser we found the nature of primary color R, G, B that they are of increasing nature or decreasing nature.

4 Noise removal
Because of atmospheric noise as well as due to motion on conveyor belt some blurs effect comes in picture. So filtering is required here. We checked all the filters and found that median filter of 3X3 size is working best .its syntax is
diff_im = medfilt2 (diff_im, [3 3]);

5. Image binarisation for boundary extractionGray image is converted to binary image by deciding a particular threshold value. All pixels having value greater than decided threshold value is grouped in one region and others to other region. Corresponding syntax is
diff_im = im2bw(diff_im, threshold value);
Threshold value determination is tough job, however here we have decided it by finding histogram plot.After binarisation, object of focus is extracted from boundary, after that some morphological operations are applied. These operation increases the speed of detection as well as increase the accuracy. There are some very small areas of pixels are present which are of insignificant nature, so they are removed by function ‘bwareaopen ()’ command.
Its syntax is
diff_im = bwareaopen(diff_im, p)

6. Geometric feature selection
Here descriptions of image object which are suitable for further computer process are extracted. The function used for extracting these features is ‘regionprops’ in matlab. The features which has been extracted are area, minor axis, major axis. The syntax is
Props = regionprops(bw, 'properties');

4.2.2 Sorting mechanism

1. Sorting Based On Color

If I=1 is selected then sorting will be done on basis of color
In our experiment we have checked three colors red, green yellow. Because it's a 3 conveyor belt sorting arrangement so it is permitted to take only three colors. Now by matlab function area of all connected region are found, then out of these area maximum area is found. After that a particular threshold value is defined, if the area is greater than this threshold value than the objected is declared either red or green or yellow colored object.

2. Sorting based on size
If i=2 is selected then sorting will be done on basis of size
Grading the vegetables on basis of size is very important criterion related to its market value as well as the packaging factor. Vegetable are sorted either low sized or medium sized or high sized vegetable. Descriptors 'area', 'minor axis' as well as 'major axis' have been used for finding size.

3. Sorting based on quality
If i=3 is selected than sorting will be done on basis of quality
Grading vegetables on basis of quality is very important factor, for health benefits .here we done our experiment on tomatoes. There are several factors which decide the quality of tomatoes. We have checked quality on basis of whether its spotted tomato or spotless.
For finding defects or spots we following steps were done
1. With the help of matlab function 'regionprop' first 'centroid' and 'bounding box' were found.
2. Then this bounding box was passed to overall binary image and all pixel values were checked. Pixel location where value found is zero is counted. This is done because all the pixel location where there is any defect that will appear as black.
3. Then particular threshold value is selected by user if the counted value is greater than the threshold value than the tomato will be declared as defected, otherwise it's a good tomato.
All algorithms for image processing were written in MATLAB 7.12.0.635(R2011a). (The Math-works, inc, USA). Figure 4 in next page showing flowchart sequence of the work done in this research

5. Result and Analysis

In the MATLAB part we are using three toolboxes- Image Acquisition, Image processing & serial communication. The Proposed working of the MATLAB code is to work in three different modes. The mode is to be selected by the user. Mode 1 is color based sorting of the vegetable. Mode 2 is the size based sorting of the vegetable. Mode 3 is spot detection and sorting of the vegetable of the same type. Basically this sorting is for quality evaluation purpose. Because fruits or vegetables which are spotted more than a particular threshold they can be declared as rotten fruit or vegetable. In mode one the camera takes the continuous images using image acquisition. The captured image is converted image is subtracted from the R index (for red color), G index (for green color) and RGB index for yellow color. The subtracted image is converted into B/W on the basis of thresholding. The Image is noisy so we are using medfilt to filter the converted image. After conversion the vegetable part in the image turns white else all is black. The area of the white part is calculated. The MATLAB interface uses serial communication to send the flag values as ASCII to controller unit as ASCII characters. The controller interface is programmed to receive the characters and perform the sorting at three different locations

Now in mode 1 if area is positive for red then red flag turns 1 else 0. Similar process occurs for green and yellow colored vegetables. Snapshots of the processed images are shown in figure for color sorting original image and corresponding its binary image is shown in figure 3**.**

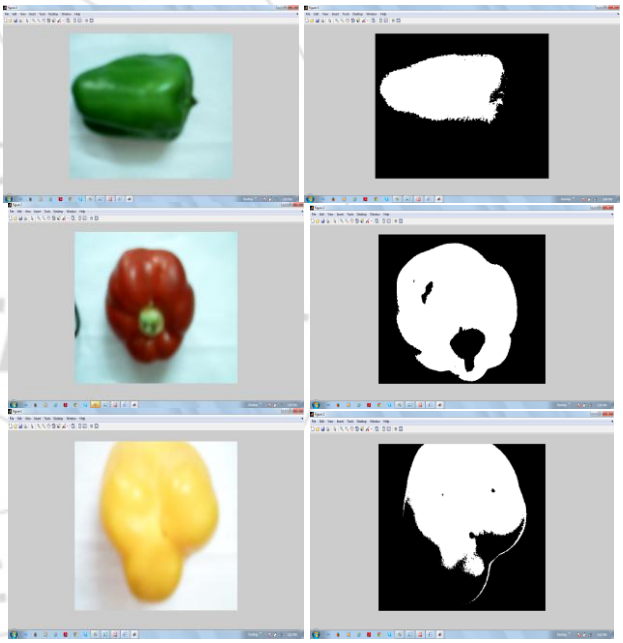


Figure 3: Resultant image obtained in color based sorting

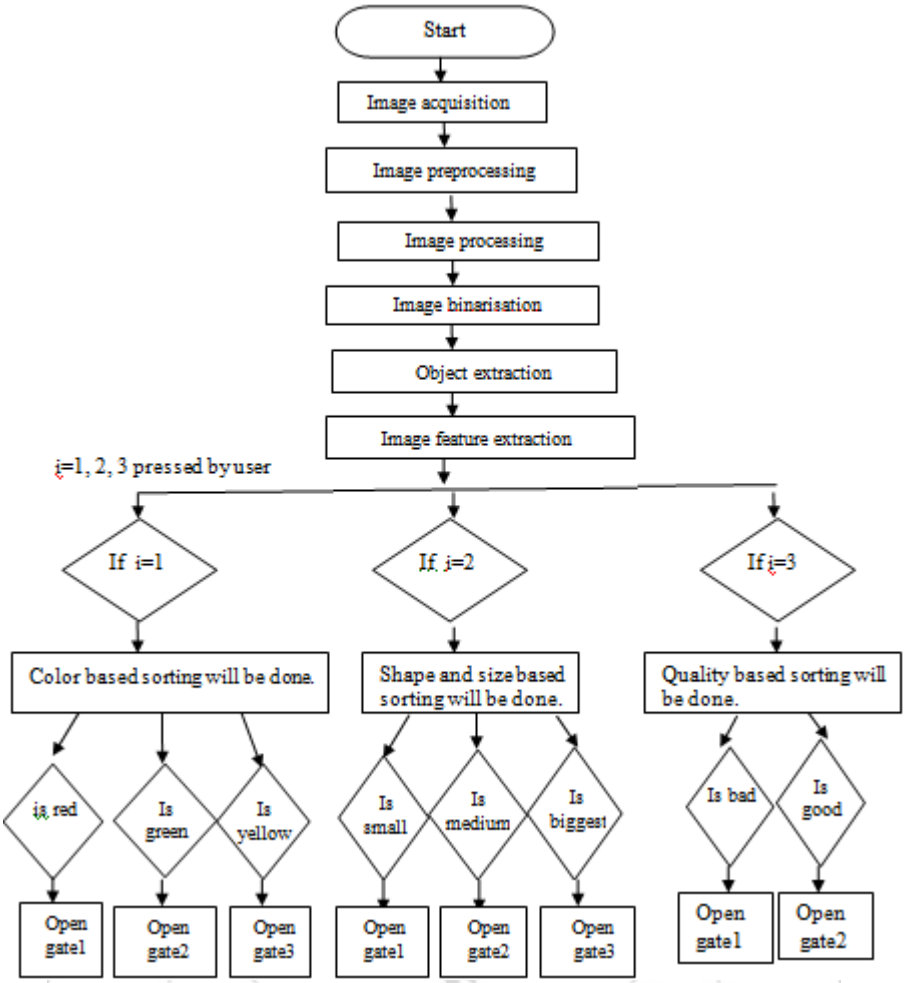


Figure 4: flowchart of complete work in this research

In mode2 the flag value turns 1, 2, and 3 as per the area threshold of different values. Shape and size classification are very important for packing purpose. Here we have taken tomato for our analysis part. Size is estimated by calculating the area covered by tomato. To capture area, first the tomato is binarised to separate the tomato image from its background. Then the numbers of white pixels are calculated which gives us the estimation of area. Tomatoes are classified in three categories according to the projected White areas as shown in fig 5. Table1 shows the range of pixels value for considering big,, medium, and small tomato Similar is the case for green & yellow color part.

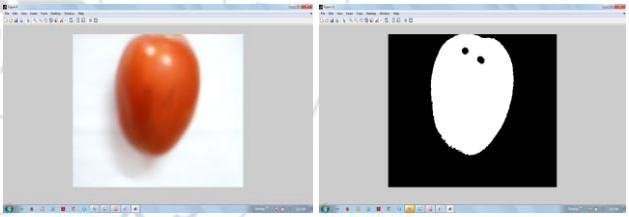
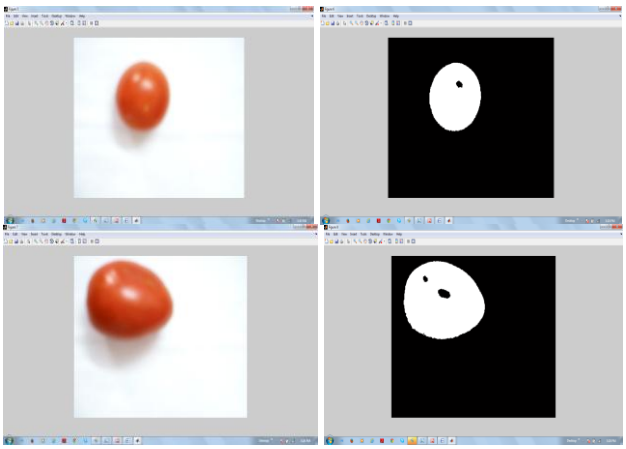


Figure 5: Resultant image obtained in shape and size based sorting

Table 1: showing projected white pixel area for classification based on size of tomato

Grading tomato	no	Min. (pixel)	Max. (pixel)	Average (pixel)
Small category	14	1000	80000	40500
Medium category	23	80000	170000	125000
Big category	55	170000	250000	210000



Mode 3 is spot detection. For spot detection we are creating a bounding box across the white detected region. In that region we are checking for number of zeros found. If the number of zeros (black pixel) is greater than a threshold which is decided by user than t red spot _flag or goes high else its zero, thus good quality and bad quality fruits or vegetables can be distinguished. Here while experiment we have taken red colored tomato for spot detection, but we can choose any colored vegetable, just we will have to do little calibration. Snapshots of the processed images for spotted tomato i.e.

defected tomato original image and corresponding its binary image is shown in figure 6.

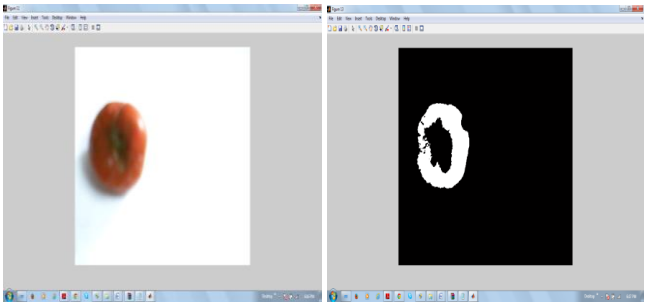


Figure 6: Resultant image obtained in quality based sorting

References

[1] Shapiro, Ll.G.And Stockman, G.C, "Computer Vision", prentice hall, upper sadle river, nj, 2001.
[2] Sonka, M., Hlavac, V. Boyle, R.: "Image Processing, Analysis, And Machine Vision" - 2nd Ed., Pws, Pacific Grove, Ca, 800 P., 1998.
[3] Md. Rokunuzzaman1, H. P.W. Jayasuriya2, " Development Of A Low Cost Machine Vision System For Sorting Of Tomatoes, " Agric Eng Int: Cigr Journal, Vol. 15, No.1 173, March, 2013.
[4] Amer Eissa A.H., A.H. Gomaa; G.R. Gamea; E. Elsaiedy; Y. F. Sharobeem; A.A. Ibrahim "Machine Vision Simulation For Sorting Orange Fruits" Journal Of Applied Sciences Research, 8(7): 3211-3224, 2012 Issn 1819-544x
[5] S. Nashat A. Abdullah ,S. Aramvith,M.Z.Abdullah "Support Vector Machine Approach To Real-Time Inspection Of Biscuits On Moving Conveyor Belt" ,Computers And Electronics In Agriculture Volume 75, Issue 1, Pages 147–158, , January 2011
[6] Majid Dowlati, Seyed Saeid Mohtasebi, Mahmoud Omid, Seyed Hadi Razavi, Mansour Jamzad, Miguel De La Guardia,Freshness Assessment Of Gilthead Sea Bream (Sparus Aurata) By Machine Vision Based On Gill And Eye Color Changes",Journal Of Food Engineering, Volume 119, Issue 2, Pages 277-287, November 2013.
[7] Yousef Al Ohali; Computer Vision Based Date Fruit Grading System: Designand Implementation; Journal Of King Saud University – Computer And Information Sciences 23, 29–36, 2011
[8] Paul H. Heinemann, Niranjan P. Pathare, Charles T. Morrow;"An Automated Inspection Station For Machine-Vision Grading Of Potatoes; Machine Vision And Applications" 1996, Volume 9, Issue 1, Pp 14-19.

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