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Automatic Velocity and Time Measurement of Falling Object with Image Processing

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Abstract This paper provides effective techniques that can be used to accurately measure the velocity of a falling object by recording the object's fall video on camera. Here, I have dropped two deferent sized objects and captured its video. Applied a series of image processing algorithms on capture video for separation of video frames, background removal, object size detection & velocity estimation with help of MATLAB software. The expected velocity and fall time successfully produced by software, the same was compared with theoretical free fall kinematic equations results.

Index Terms— Image Processing, Object fall, Velocity measurement,

I. INTRODUCTION

Earth's gravity pulls all objects toward its center, and near the Earth's surface. Objects in free fall accelerate at 9.8 m/s2 vertically downward, provided air resistance is negligible. There are many ways to measure object fall acceleration and time, such as using a stopwatch or electronic sensor. Recent advances in computer vision techniques have led to increasing interest in the use of vision as the only mechanism to estimate the object speed in certain applications.

Here, I performed a free fall experiment, by recording the drop of a ball and cardboard box from a height of 1.75 meters without causing any initial spin. The footage of the item was captured with a camera that had a frame rate of 120 frames per second. The captured video is uploaded and files location feed to code for execution in MALAB.

Index Terms—*Velocity measurement, Image Processing, Object fall*

I. EXPERIMENTAL TECHNIQUES

a. Experimental setup

The setup consists of a vertically positioned camera on a stand with a frame rate of 120 frames per second and a resolution of 1280x720, as seen in figures 1. Object dangles with thread 25 centimeters below the camera. The object was kept 175 cm from the ground. Two objects are dropped as part of the experiment. The first object was a ball with a diameter of 6 cm, and the second was a box with dimensions of 20 cm by 25 cm by 10 cm and a red sticker 10 cm diameter on top, photo shown in figs. 1. This experiment was performed at home.

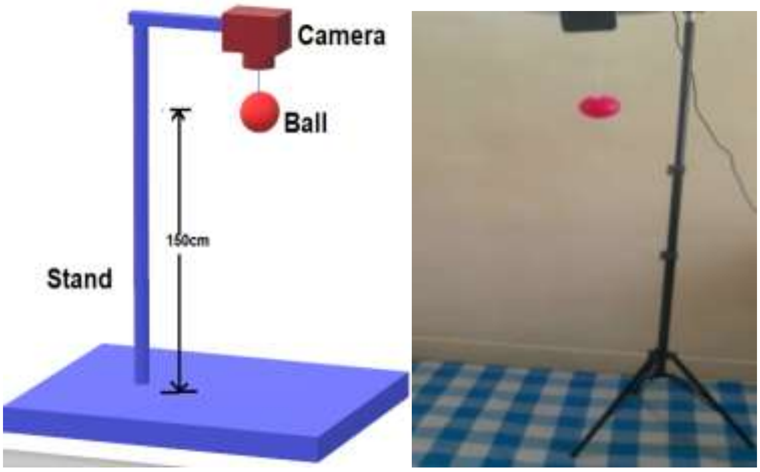


Fig 1. Set up for dropping ball

b. Video Recording

Set camera on recording mode and dropped both object one by one with no initial velocity in closed room (minimum air resistance). Recorded videos consist of 3 sec each uploaded into computer.

c. Matlab Simulation

The code is designed with existing available MATLAB functions of image processing. The code flowchart are shown below (fig 3).

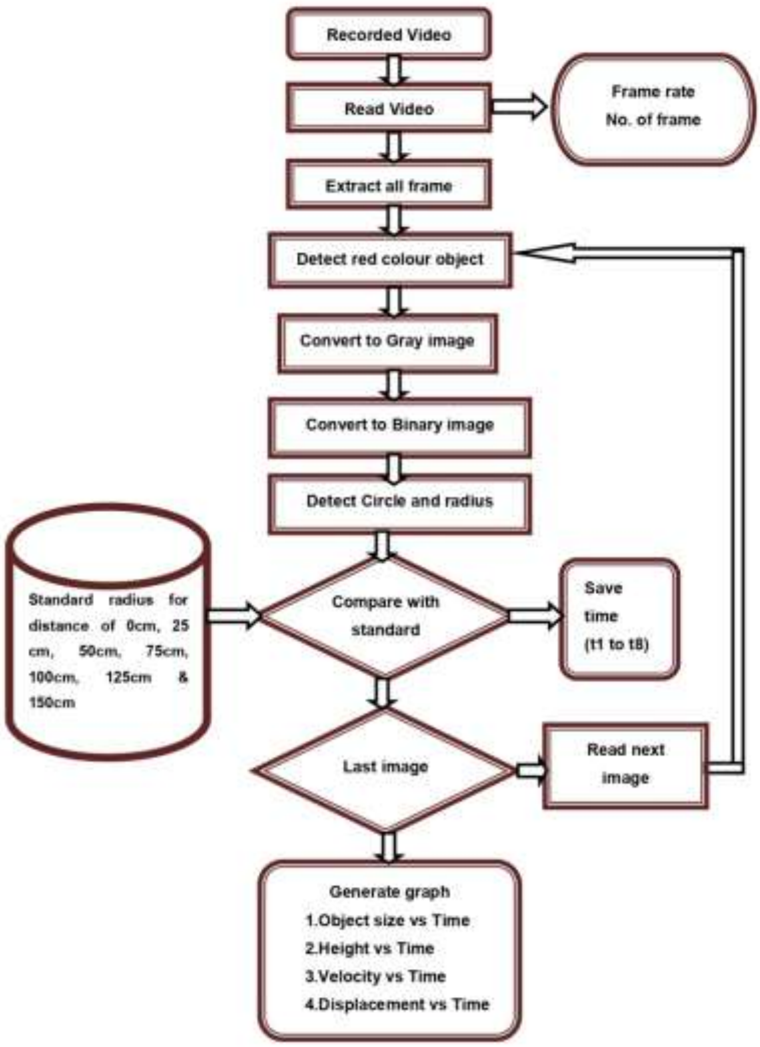


Fig 3 Process Flowchart

II. Free fall theoretical calculations

If object drop from 'd' height its free fall time can be calculated by kinematic equations

d = Vi •t + ½ • a • t2

Where d=displacement, t=time, a = acceleration of the object, vi = initial velocity

An object in free fall experiences an acceleration of 9.806 m/s^2.
a=9.8, Vi=0,
for displacement d=0.25, 0.50, 0.75, 1.0, 1.25, 1.50, 1.75 calculated fall time= t1, 2, t3, t4, t5, t6, t7, t8.

$t1^2=2\bullet 0/9.8$;
t2=0.0 sec …………(1)
$t2^2=2\bullet 0.25/9.8$;
t2=0.2258 sec …………(2)
$t3^2=2\bullet 0.50/9.8$;
t3=0.3193 sec …………..(3)
$t4^2=2\bullet 0.75/9.8$;
t4=0.3911sec ……………(4)
$t5^2=2\bullet 1.0/9.8$;
t5=0.4516sec …………(5)
$t6^2=2\bullet 1.25/9.8$;
t6=0.5049sec …………(6)
$t7^2=2\bullet 1.0/9.8$;
t7=0.5531sec …………(7)
$t8^2=2\bullet 1.0/9.8$;
t8=5.974sec …………(8)

III. MATLAB simulation

a. Video read output

i.Video input

ii. Video read command window

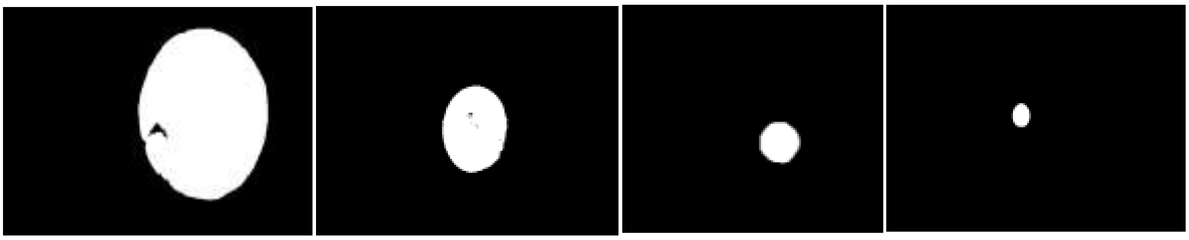
```
Summary of Multimedia Reader Object for 'box4.mp4'.

  Video Parameters:  120.03 frames per second, RGB24 1280x720.
                     400 total video frames available.
```

```
Summary of Multimedia Reader Object for 'ball.mp4'.

  Video Parameters:  120.03 frames per second, RGB24 1280x720.
                     390 total video frames available.
```

b. Extracted frames form video

Box (Frame 1) Ball (frame 1) Box (Frame 300) Ball (frame 350)

c. Processed frames form video



Box (Frame 1) Ball (frame 1) Box (Frame 300) Ball (frame350)

Frames shown above are first and last of video, remaining frame shown in Fig.4 and Fig. 5

d. Command window output showing Time with respect to distance travel by ball

```
timev =

      0    0.2250    0.3250    0.3917    0.4666    0.5166    0.5666
```

```
distance =

      0    0.2500    0.5000    0.7500    1.0000    1.2500    1.5000
```

```
v =

      0    2.2223    3.0770    3.8299    4.2859    4.8389    5.2943
```

e. Command window output showing Time and velocity with respect to distance travel by box

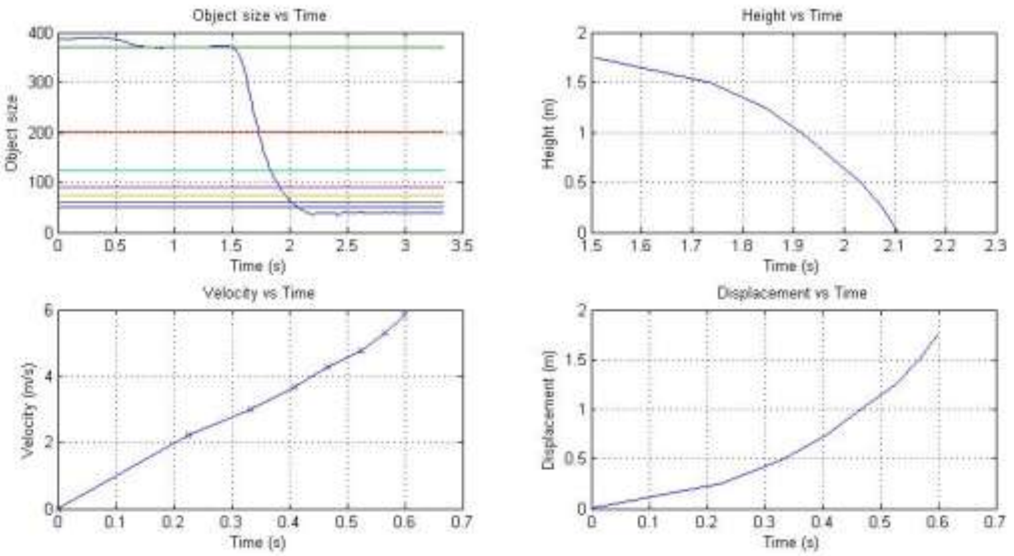
```
time =

      0    0.2250    0.3333    0.4083    0.4666    0.5250    0.5666    0.6000
```

```
distance =

      0    25    50    75    100    125    150    175
```

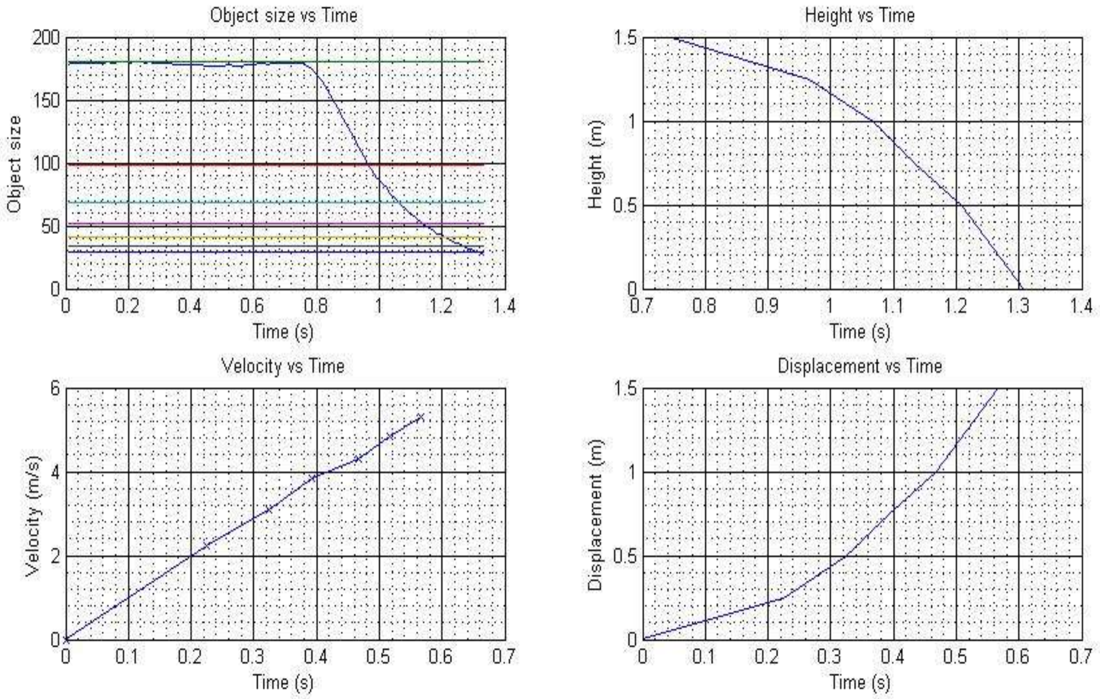
```
v =

      0    2.2223    3.0001    3.6736    4.2859    4.7621    5.2943    5.8336
```

IV. Results

a. Output graph for box drop experiment



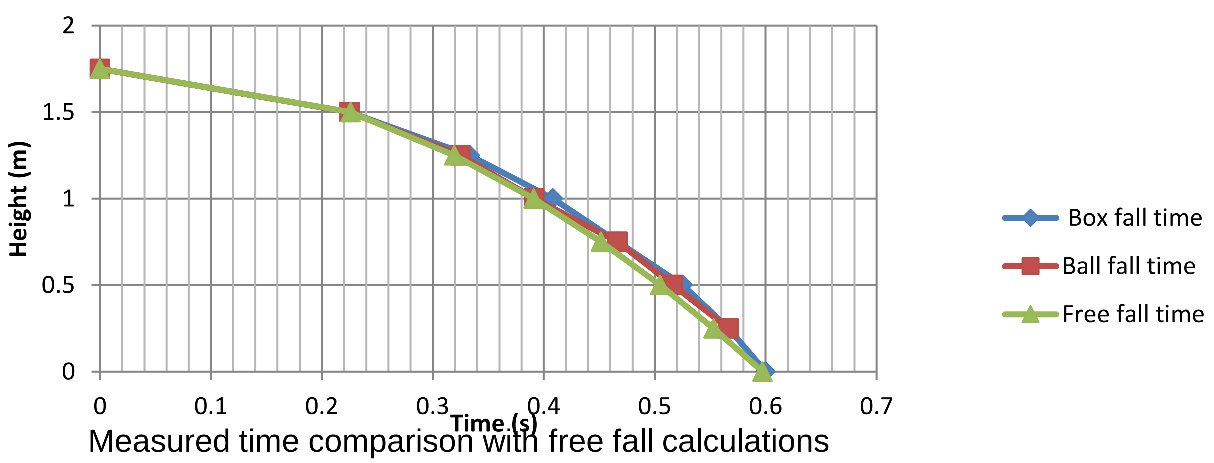
b. Output graph for ball drop experiment



c. Comparison table of simulation result and theoretical result

Sl. No.	Distance (cm)	Time (s)			velocity	
		Simulation Result (for Box)	Simulation Result (for ball)	Theoretical Calculation	Simulation Result (for Box)	Simulation Result (for ball)
1	0	0	0	0	0	0
2	25	0.2250	0.2250	0.2258	2.2223	2.2223
3	50	0.3333	0.3250	0.3193	3.0001	3.0770
4	75	0.4083	0.3917	0.3911	3.6736	3.8299
5	100	0.4666	0.4666	0.4516	4.2859	4.2859
6	125	0.5250	0.5166	0.5049	4.7621	4.8389
7	150	0.5666	0.5666	0.5531	5.2943	5.2943
8	175	0.6000	-	0.5974	5.8336	-

d. Results comparisons in graph



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Conclusion

The ball drops from a height of 1.5m and the box drops from a height of 1.75m. Its video is recorded & processed successfully using Matlab image processing with a displacement in step size of 0.25 m. executed code detect & track objects automatically. Object fall time measure for 0.25m distance intervals. These results are compared with theoretical calculations found by close matching. This time & velocity measurement method may be used for different applications. It has been suggested that use a higher frame rate camera in order to get minimum interval distance tracking and more accurate results.

References

[1] Masniezam Ahmad and Khairul Azwan Ismail “Velocity Measurement of a Sports Ball during the Drop Test by a High-speed Camera” International Journal of Mechanical Engineering and Robotics Research Vol. 8, No. 2, March 2019

[2] John Pickle ”Measuring the Acceleration of Falling Objects”

[3] Madhur Garg,Kalimullah,and P.Arun ”Accurate measurement of the position and velocity of a falling object” Am.J.Phys.,Vol.75,No.3,March2007

Fig. 4 Extracted frames for ball drop

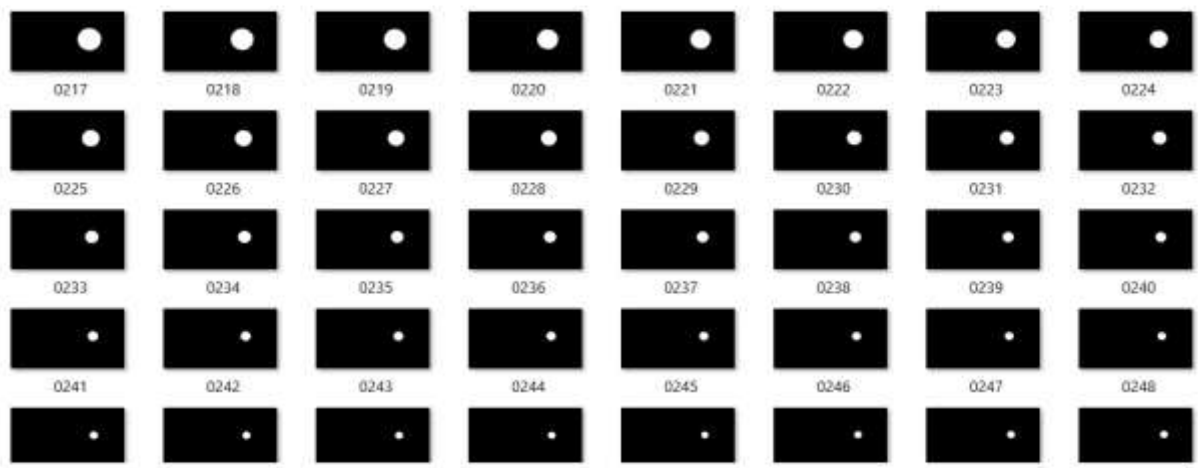

Fig. 5 Processed frames for ball drop