An Automated Tracking System for Y-Maze Behavioral Test using Kinect Depth Imaging

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I. Introduction

- ❑ We have developed an image processing system for automated tracking and behavior analysis of the popular Y-maze test on freely behaving rodents, using depth imaging, provided by a Microsoft Kinect® 2D/3D imager.
- ❑ The system tracks the animal position and Y-maze arm entry sequence for calculating spontaneous alternation and other widely accepted measures for analyzing the working memory and ambulatory activity.

II. System Overview

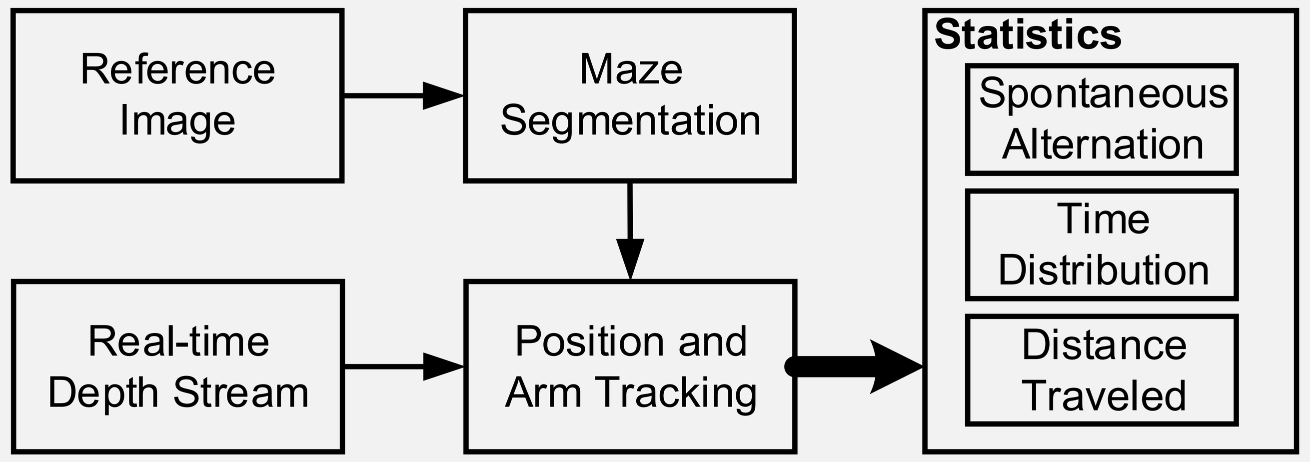

Fig. 1. Block diagram of the proposed system for Y-maze behavioral test.

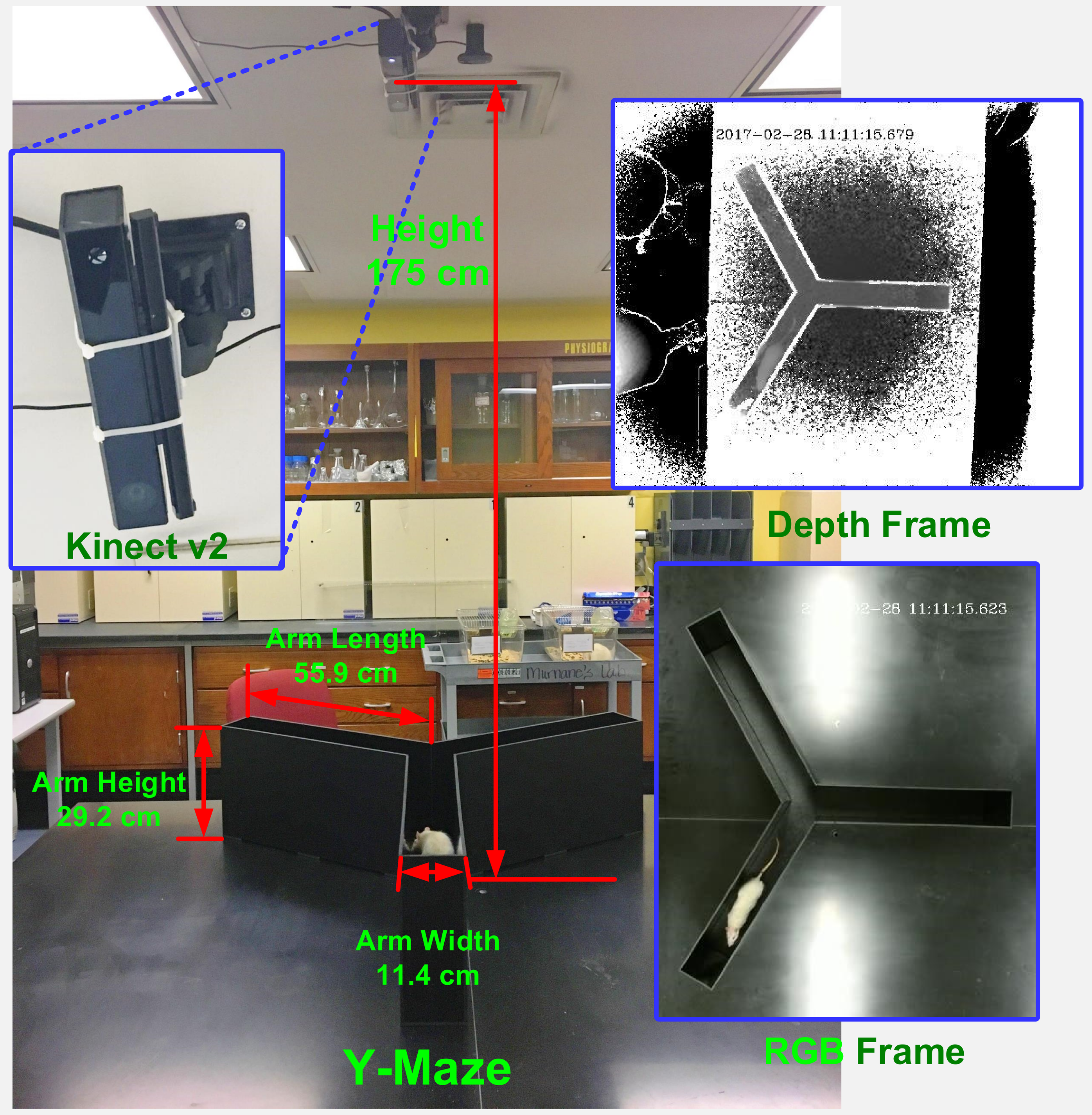

Fig. 2. In vivo experiment setup.

Automated Y-Maze Segmentation

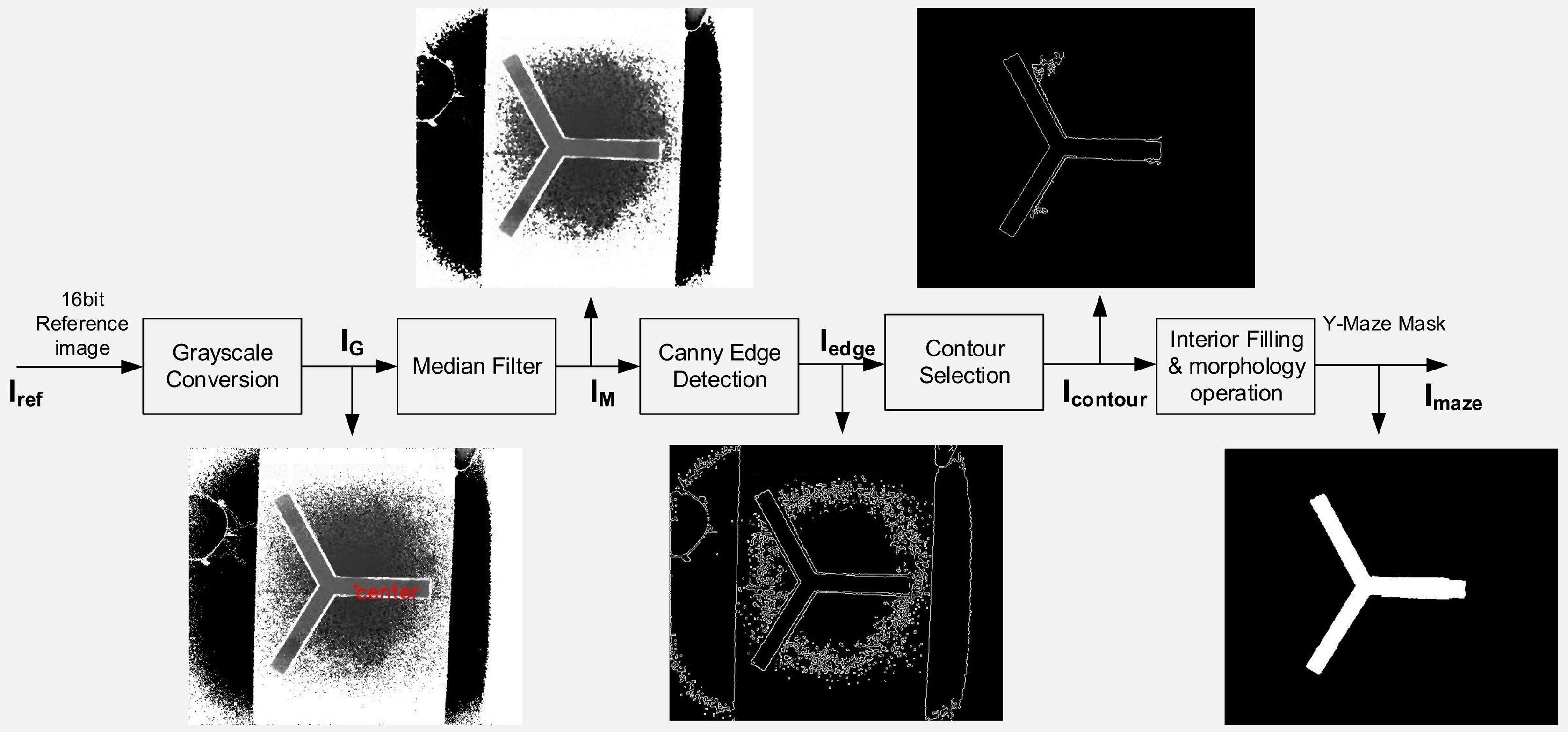

Fig. 3. Flowchart of the image processing algorithm used for segmenting the maze from the reference image (without animal subject).

1. The maze shape is identified by an automated segmentation algorithm.
2. Exploiting the geometric features of the Y-maze, a contour-based method is used to divide the maze shape into four parts, three arms and a center piece.

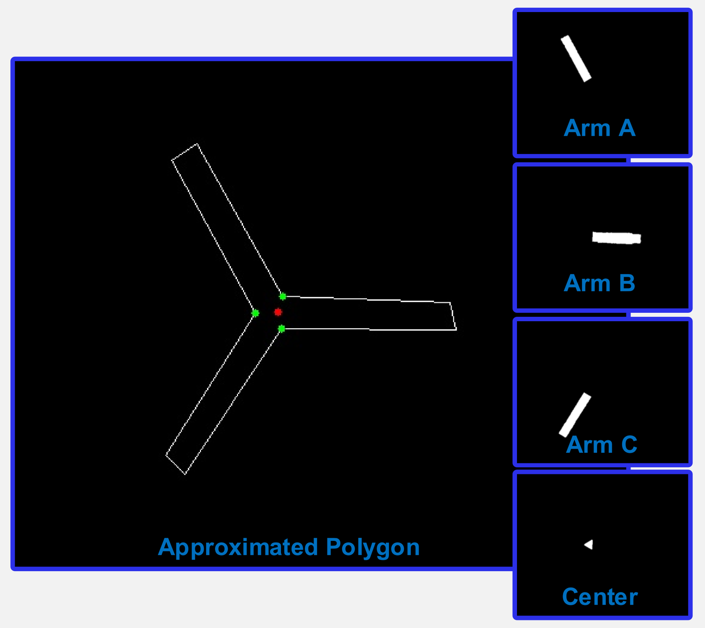

Fig. 4. Extraction results

Table I. Jaccard Index Between Algorithm and Manually Segmented Results

	Whole Maze	Single Arm	Center Part
Averaged Jaccard Index	0.950	0.940	0.746

Position and Arm Tracking

3. To obtain the rat body contour, an extraction algorithm based on background subtraction is used.
4. Using the rat mask along with the arm extraction results, algorithm 1 decides the rat is in which arm.

Algorithm 1 Algorithm for determining rat's arm location

Input: rat mask I_{rat}, maze parts I_A, I_B, I_C
previous location p_{pre}

Output: rat's arm location p

$Found = False$
Calculate rat area S_{rat} from I_{rat},
for $i = A$ to C **do**
  Calculate overlap area S_i between I_A and I_{rat}
  if $(S_i > 0.99 * S_{rat})$ **then**
    $p = i$
    $Found = True$
  end if
end for
if $(Found \neq True)$ **then**
  if $((p_{pre} \neq center)$ AND $(S_i > 0.01 * S_{rat}))$ **then**
    $p = p_{pre}$
  else
    $p = center$
  end if
end if
return p

III. Experimental Results

- ❑ Functionality of the system was verified *in vivo* with 7 adult, male, Sprague-Dawley rats.
- ❑ For all 7 rats, comparisons between the arm entry sequence generated by the system and by human annotations showed **100% agreement**, with less than 0.1 s error in time stamps of "enter/leave" actions.
- ❑ Behavioral Results
  - ➢ Spontaneous Alternation:

$$Alternation\% = \frac{Number\ of\ Alternations}{Total\ Number\ of\ Entries - 2} \times 100\%$$

  - ➢ Time Distribution
  - ➢ Distance Traveled

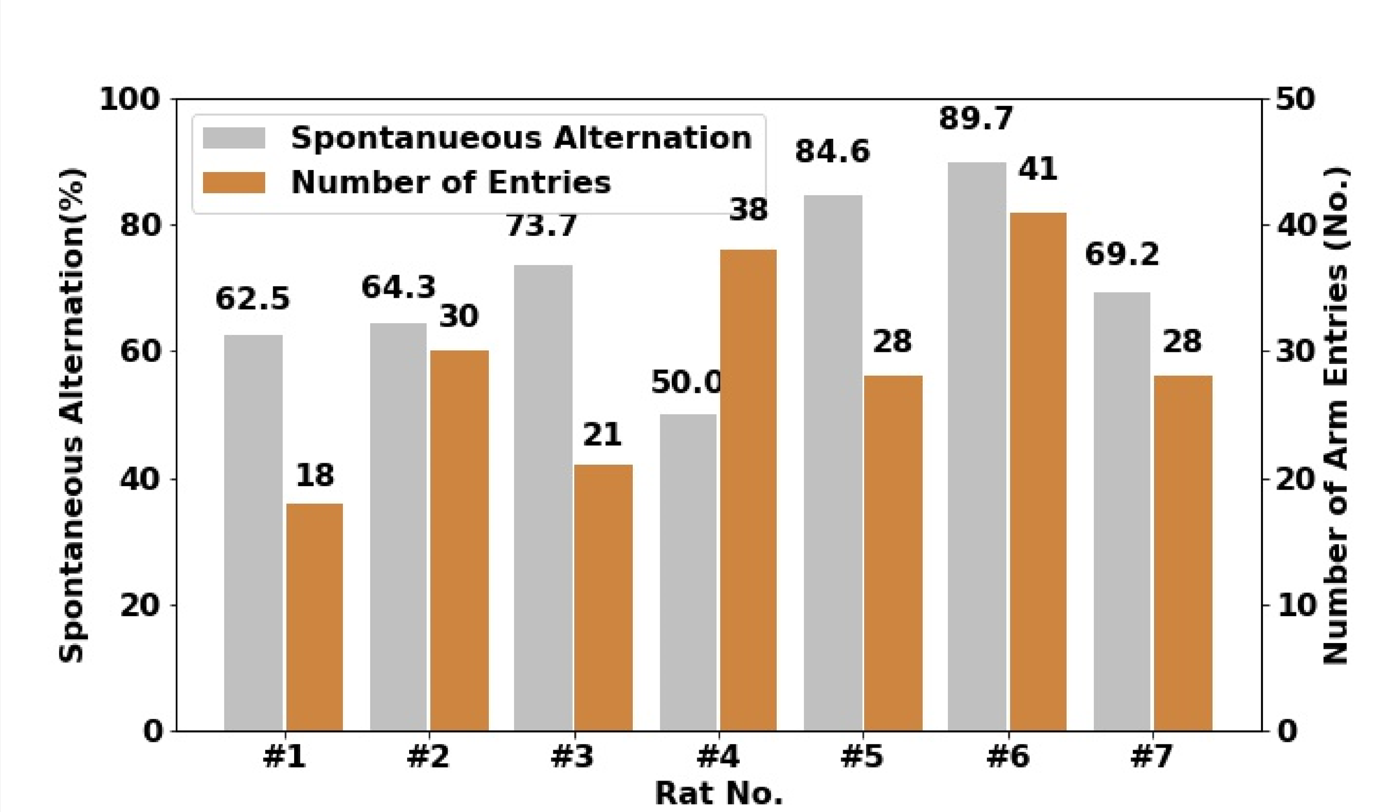

Fig. 5. Spontaneous alternation results

Table II Tracking results of each session

Rat No.	Time Distribution among maze parts				Total Time (s)	Distance (m)
	Arm A	*Arm B*	*Arm C*	*Center*		
#1	46.7%	23.1%	24.5%	5.7%	621.0	48.13
#2	41.0%	20.0%	35.2%	3.8%	611.9	69.43
#3	47.5%	33.4%	18.3%	0.8%	615.1	53.67
#4	28.7%	27.5%	38.9%	5.0%	608.0	84.12
#5	29.8%	39.0%	28.4%	2.8%	719.8	71.81
#6	26.8%	33.8%	32.8%	6.7%	663.0	83.76
#7	37.4%	32.8%	28.4%	1.4%	543.6	61.81

IV. Conclusion

- ❑ The use of depth image eliminates the need of high color contrast between animal subject and the maze, enables consistent output regardless of lighting condition.
- ❑ Future work includes extending the tracking to T-maze and radial-maze, and using the algorithm in scientific and preclinical research experiments.

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