

# Development of a Jenga Game Manipulator Having Multi-articulated Fingers

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## ABSTRACT

This paper describes current status of our effort to develop a robot system that can play Jenga game against human players. Unlike most of the previous Jenga robots that use grippers, this robot is equipped with a hand with two multiarticulated fingers covered by soft skin and does not have any major mechanical constraint in playing the game in a natural way as human players do. An experimental result of a game played between the robot and a human player is presented.

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General Terms: Experimentation

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## 1. INTRODUCTION

Recently various game playing robots have been developed. Among them, there are several works on robots that play Jenga [1] [2] [3]. They all use either grippers that are custom-made for Jenga or simple grippers available on the market.

In this paper, we use a robot manipulator having a versatile hand with two multiarticulated fingers which we have been using for research of advancing grasping and manipulation skill of multifingered hands [4] [5]. Note that we have reported on a preliminary study of this system in a previous paper [6]. Since then several major improvements have been implemented: (1) Time needed for visual information processing was made shorter by replacing the omnidirectional camera by a simple monocular camera and by reducing the number of necessary images, (2) ordinary Jenga blocks commercially available are now being used for experiment due to the thinner fingertips we are using now (in [6] blocks made of two regular blocks bonded together were used, and (3) the fingers grasp a block from the side instead of grasping it from the top, making it possible to play with higher Jenga tower (In [6] playing with only three level towers were possible). Results of these improvements are presented in this paper.

## 2. TASKS NEEDED IN PLAYING JENGA

The tasks needed in playing the game can be divided into the following five basic tasks.

1. Recognition of the shape of the tower.
2. Selection of the block to be removed.
3. Performing the motion of removing.
4. Selection of the position for putting the removed block on the top level.
5. Performing the motion of placing the removed block back.

Tasks 2 and 4 correspond to the strategy and tasks 3 and 5 correspond to the skill of the game. Our approach for performing each of these tasks is explained below.

### 2.1 Recognition of Block Positions

The block positions in the tower is recognized using the images taken by a monocular camera attached to the base of the hand (camera in hand).

### 2.2 Selection of Block for Removal

Search for candidate blocks for removal is done based on the consideration that the tower should not fall after removing the block. The basic idea here is that a sufficient condition for the stability of the tower is that the vertical line going through the center of gravity of the set of all blocks from the top level to a certain level  $k$  (counted from the bottom) intersects with the support region defined by the smallest convex set including all the upper surfaces of the blocks in level  $k - 1$ . If there are multiple candidate blocks, then we select one block based on a evaluation function representing the degree of danger. Currently the safest block is selected according to this degree of danger, although there can be other strategies that do not select the safest one.

### 2.3 Selection of Place for Putting Block

Selection of the place for putting back the removed block on the top level is also done in a similar way to that of removal block selection.

### 2.4 Removing Motion

One difficulty in playing Jenga game is that the size of the blocks slightly differ to one another. Because of this the difficulty of removing a block varies even if the geometrical condition of the block in the tower is the same. To cope with this problem, the following scheme is adopted. After grasping the block, the angle of the grasped block is slightly tilted. By this tilting, it is expected that the the contact point will move to the outside edge of the block and the

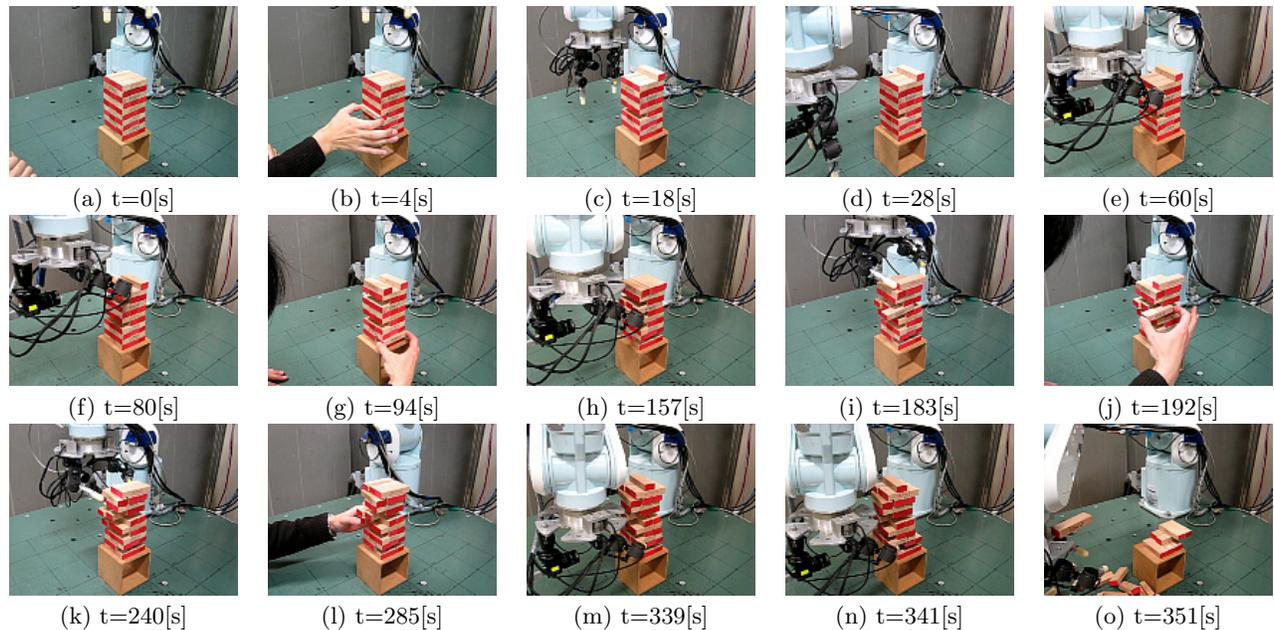


Figure 1: Experiment of match-up

distribution of the load among the blocks on the level of removal block will change, hopefully, in such a way that the load of the block of removal will decrease.

## 2.5 Putting Motion

When a human player performs the putting motion of a block on the top of the tower, it is done so that any large impact force may not be applied to the tower. One way for achieving this by the robot is to detect the contact between the block and the top surface of the top level of the tower by using the force sensors at the fingertips.

## 3. EXPERIMENT OF MATCH-UP

Experimental match-ups between the robot and a human player was performed using ten level tower consisting of 30 blocks. Fig.1 shows a case in which the robot performed very well. Fig.1(a) was the initial state. The human player took the turn first. The human player removed a block from level 5 (Fig.1(b)) and put it back to the top (Fig.1(c)). Then the human player signaled the completion of his turn. Note that the game proceeds automatically except for a signalling by the human player of the completion of his motion by clicking a key of a PC controller of the robot. Receiving this signal, the robot started to take two images of the tower from two neighbouring sides (Fig.1(c) and (d)) to estimate the positions of the blocks in the tower by using the camera. After repeating this process several times the robot, as its fourth move, tried to remove a block from level 2 (Fig.1(m) and (n)) but the tower collapsed (Fig.1(o)).

## 4. CONCLUSIONS

Although the present level of the robot system in performing the game is still very low, A variety of ideas could be tried in this system to improve the skill of the system.

We believe that a robot system that has a hand similar to humans will be important for playing Jenga with human players.

## 5. REFERENCES

- [1] T. Kröger, B. Finkemeyer, S. Winkelbach, L.-O. Eble, S. Molkenstruck and F. M. Wahl, "A Manipulator Plays Jenga," IEEE Robotics and Automation Magazine, vol.15, no.3, pp.79-84, 2008.
- [2] J. Wang, P. Rogers, L. Parker, D. Brooks, M. Stilman, "Robot Jenga: Autonomous and Strategic Block Extraction," In Proc. of The 2009 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, pp.5248-5253, 2009.
- [3] S. Kimura, T. Watanabe, Y. Aiyama, "Force Based Manipulation of Jenga Blocks," In Proc. of The 2010 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, pp.4287-4292, 2010.
- [4] Tsuneo Yoshikawa, "Multifingered Robot Hands: Control for Grasping and Manipulation," Annual Reviews in Control, vol.34, issue 2, pp.199-208, 2010.
- [5] T. Yoshikawa, M. Koeda, and H. Fujimoto, "Shape Recognition and Optimal Grasping of Unknown Objects by Soft-Fingered Robotic Hands with Camera," Experimental Robotics: The 11th International Symposium, Springer Tracts in Advanced Robotics, pp. 537-546, Vol. 54, 2009.
- [6] T. Yoshikawa, H. Shinoda, S. Sugiyama, and M. Koeda, "Jenga Game by a Manipulator with Multiarticulated Fingers," Proc. AIM2011, pp.960-965, 2011.