MoleBot: Mole in a Table

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1. Introduction

What would it be like to have a mole live under your table and push around objects on the table surface? We have developed MoleBot, a robotic mole living in a coffee table that interacts with small items laid on the table surface. The MoleBot projects a molehill on the surface, which moves simultaneously with the movement of the MoleBot. In order to make the molehill move with fluidity, the table surface needs to be rigid yet flexible. Various techniques used in shape display and organic user interfaces of previous projects (Feelex, Pop Up!, Lumen1, Relief2, and HypoSurface) were assessed to determine the feasibility of the molehill idea. The projects adopted servo motors, shape memory alloys, electric slide potentiometers, and pneumatic actuators. However, in generating the MoleBot, these techniques were unable to concurrently provide the necessary speed of actuation, resolution, and pixel size for desired level of physical interactivity with objects on the surface. As a result, we conceived a new way to implement this concept.

2. Implementation

It was essential to make the rigid surface of the table flexible enough to implement a smooth movement of the molehill. We transformed a 700 by 700mm table surface into a tessellation of more than 15,000 small hexagonal pins. The pins are inscribed in a circle that is 6 mm in diameter and close-packed just like a honeycomb. The pins can move up and down to create a molehill. We designed a two-dimensional translating cam that has the same shape as a molehill, called mole cam. The mole cam is allocated just underneath the pins. As the mole cam moves on the XY plane, the hexagonal pins create linear motion along the direction of gravitational force like a cam follower. We put an 8mm Bakelite sheet underneath the pins and the mole cam to support them and then set up a XY stage with two stepper motors underneath the sheet to actuate the mole cam. The head of the XY stage has a strong neodymium magnet, which pairs up with another magnet in the mole cam. As a result, the movement of the head of the XY stage can be transmitted to the mole cam and then to the pins, generating an organic physical deformation of the rigid table surface (Figure 1).

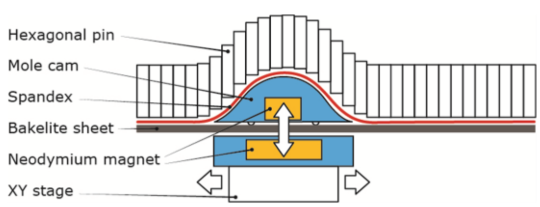

Figure 1. *Sectional view of the MoleBot.*

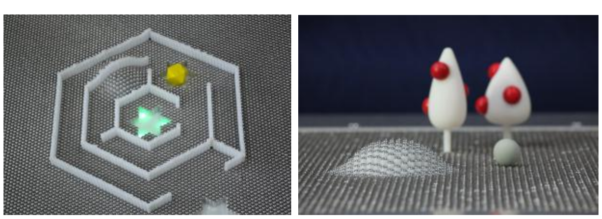

Figure 2. *Hexagonal maze(a) and fruit picking(b).*

MoleBot is able to move as swiftly as up to 40cm per second. However, lots of friction is created between the mole cam and the pins as the MoleBot moves. We made all the pin spherical faced but that was not enough to reduce the friction effectively. Hence, we solved the problem by inserting a sheet of spandex between the mole cam and the pins. MoleBot can interact with physical object in two different ways. It can either push objects by means of the force from the mole cam or pull something sensitive to magnetism with the neodymium magnet in the mole cam.

3. Application

The MoleBot is intended to be a novel game platform rather than a general shape display. Hexagonal pixels can be replaced with various small props, allowing people to build a miniature world on the table similar to that of a game board and control the MoleBot to interact with those props. Additionally, the MoleBot can interact with any small objects of choice, giving people the creative freedom to design their own world of games with personal and/or mundane items. We propose three different types of games with the MoleBot as follows.

(a) Hexagonal maze: A player builds a maze by replacing some hexagonal pins with longer pins or bigger objects. The player who can control the MoleBot to fetch a ball and place it on a specific destination in the maze most quickly wins the game (Figure 2-a).

(b) Fruit picking: Hexagonal pixels can be replaced with modeled trees and flowers with fruits hanging from them. The MoleBot can shake the trees and flowers and pick up the fruits that drop. The player who harvests more fruits wins the game (Figure2-b).

(c) MoleBot soccer: We designed a small two-wheeled robot-RollBot. Two players, one controlling the MoleBot and the other controlling the RollBot, fight over a ball and the person who puts the ball into a goal first wins the game.

By expanding the MoleBot's range of interactivity and intelligence, the MoleBot could also provide great companionship for us in the near future.

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