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The Study of Game Interface Improvement due to the Game Operation Dilemma of Player in the Side-Scrolling Shooting Game

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***Abstract*—**The feature of a side-scrolling shooting game is facing the surrounding enemy and barraging in an entire screen. The player will be in trouble when they are trying to do complicated operations because of the physical and system limitations of the joystick in the games. This study designed the prototype of a type of arcade stick by focus group and assessed by the expert. We selected the most representative joystick prototype and built the control system for the joystick. We conducted two experimental tests using time and bullet consumption as objective indicators, aiming to demonstrate its efficiency in the game. Finally, the prototype of L-1 solves the dilemma of scroll shooting games when the player uses the arcade stick and improves the function of the arcade stick.

***Keywords*—**Joystick, user interface, side-scrolling shooting game, improved user experience.

I. Introduction

THE operating of an arcade stick is easy but only in easy games. The arcade stick will force a dilemma when a player is doing a complicated operation [1], because the buttons of an arcade stick (1 stick, 8 button) are less than that of a joystick (2 stick, 12 button). This problem usually occurs in scroll shooting games. Players need to move from left to the right while dodging a barrage and counter the enemies. An arcade stick has only eight directions, so player cannot aim a target in the opposite direction of moving [2]. This dilemma interrupts the game experience (see Fig. 1).

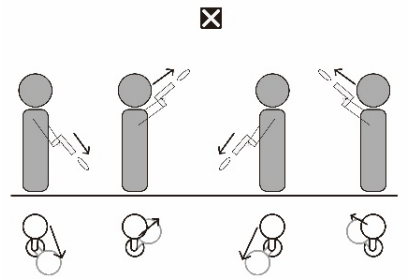

Fig. 1 Inaccurate shooting

II. Exploring Commercially Available Games

The price of an arcade stick is higher than that of a game controller. At the same time, a game controller has more functions and can be used for a wider range of game operations. Thus, players prefer to choose a joystick. According to an experiment [3], excessive repeat movement with the small button could lead to arthritis (e.g., PlayStation finger). However, side-scrolling shooting games have more complex and intense gameplay, which can potentially cause finger injuries. This shows the advantage of the arcade stick because it has a wider and more comfortable interface.

Our research focuses on sorting out the functions present in scroll shooting games available on the market, in order to understand the requirement of operation and separate to five main functions (Table I): (1) Aim & Shoot, (2) Dodge, (3) Climb, (4) Trigger, and (5) Weapon menu. These common requirements can also be generalized to Lv1 and Lv2. Moreover, while the majority of functions in scroll shooting games can be operated using a joystick or arcade stick, aiming remains a significant challenge. Therefore, our objective is to enhance the functionality of the arcade stick specifically for aiming.

III. Method

First, we designed the arcade stick interface with the input of the focus group and entrusted an expert to select the optimal program. We create a prototype of the chosen program and test its effectiveness in comparison to those already on the market through experimentation. Finally, we can get the parameters for the designer to improve the arcade stick.

A. Focus Group

A total of six students, majors in design (three in the game design department, three in product the design department), are invited to the focus group. All participants have game design and UI design experience. The focus group focused on two factors: (1) Common dilemma on arcade stick and (2) Aim function improvement. They generate ideas through discussions, videos, and hands-on exercises (Table II).

The results of the discussion led to the proposal of six interface improvements, which were divided into left-side and right-side modifications for the arcade joystick. After modeling, we 3D print and assemble the prototype (Table III).

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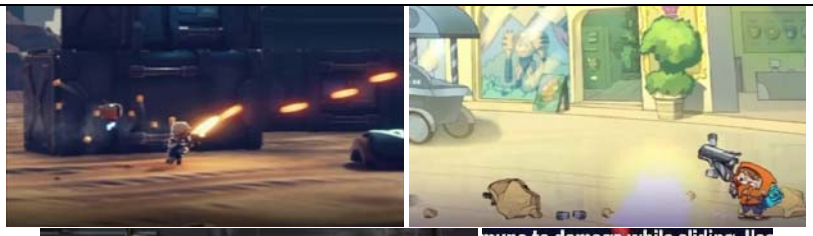
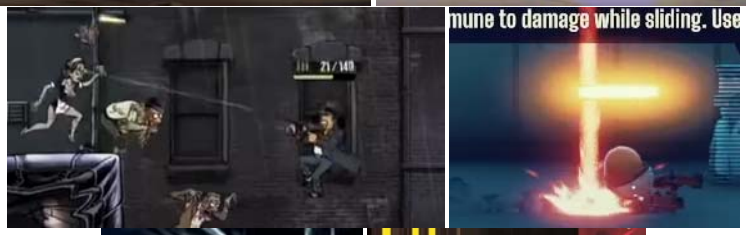
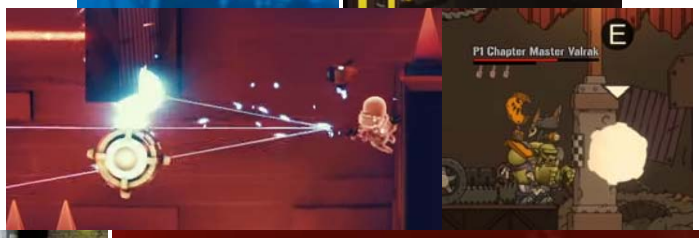
TABLE I
OPERATION AND FIVE MAIN FUNCTIONS

	Item
Aim & Shoot	
Dodge	
Climb	
Trigger	
Weapon menu	

The conclusion of the focus group suggests two reform type and six interfaces. The following are explanations of those functions:

- **L-1:** Adding a shaft on the stick as left-reform. Players rotate the grip on part B for aiming function.
- **L-2:** Adding a button on the top of the stick as left-reform. Players will need to push the button when they are going to aim. Players switch between aiming and movement modes by pressing a button.
- **L-3:** Replacing the stick with two buttons as left-reform. Players can push the button to move and push another button to turn around.
- **L-4:** Adding a rotatable axis to the joystick, allowing aiming through the rotation of the joystick.
- **R-1:** Adding a touch circle as right-reform. Players can use the touch circle when they need to aim.
- **R-2:** Adding an analog stick as right-reform. Players can use the touch circle when they need to aim.

TABLE II
DISCUSSION OF GAME OPERATION DILEMMA

Item	
Aim & Shoot	Aim & Shoot
	Aim & Shoot + Dodge
	Aim & Shoot + Climb
	Aim & Shoot + Trigger

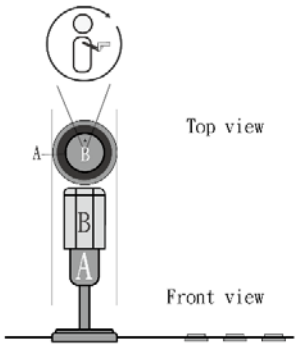
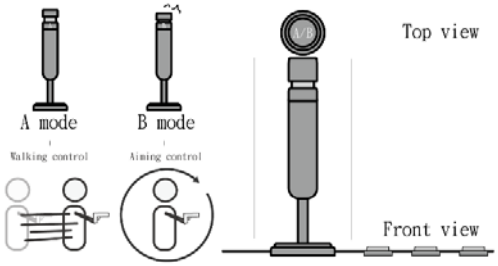
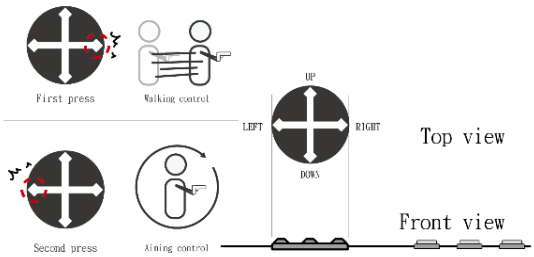
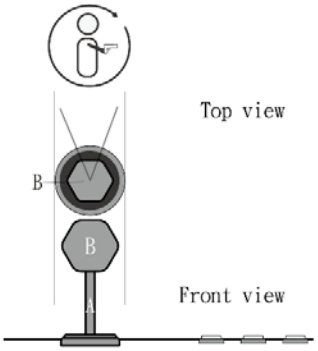
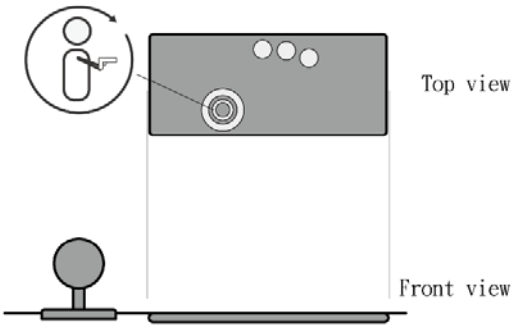
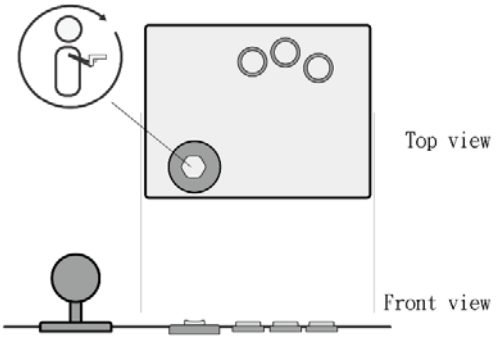
B. Expert Assessment

Our research invites an expert product designer to assess the prototype. Experts evaluate the product structure and usability as assessment criteria. We put the suggestion into two categories: (1) Reasonable interface using and crafting, (2) Unreasonable interface using and crafting (Table IV).

We found that it is reasonable for a player to operate both L-1 and L-4, as they have a similar interface. However, the simpler mechanics of L-3, L-2, R-1, and R-2 are easier to craft, but they go against player habits. We chose the most reasonable L-1 to craft the prototype, taking into consideration the player's

habits.

TABLE III
PROTOTYPE

Improve	Prototype
Left Improve (L)	 L-1  L-2  L-3  L-4
Right Improve (R)	 R-1  R-2

C. L-1 Specification and System Installation

Taking into consideration the rebound and durability of the material, we have developed a model equipped with a rotating mechanism. To accomplish this, we have chosen to utilize Selective Laser Sintering (SLS) technology to fabricate L-1.

The specification of L-1 will follow the data measured by Institute of Labor, Occupational Safety and Health, Ministry of Labor. The length of the stick is 89 mm [4] and the diameter of the stick is Ø38 mm measured in the experiment [5]. Players can hold steadily when they rotate the stick.

Considering the rotation angle of the shaft, our research developed a measuring instrument and recruited 60 participants (32 male, 28 female). We first ensured their posture during the experiment. The participants will rotate their wrists to measure the angle of wrist rotation. Finally, the measurement results were analyzed, and the rotate angle was defined as the 50th percentile value (Table V).

The system is written by Arduino Leonardo. This allows both Windows and game programs to recognize our design. We divided the rotational angle into eight directions based on mission requirements.

TABLE IV
INDUCTION AND CONVERGENCE

Improve	Prototype
Use reasonable & Reasonable process	L-1 & L-4
Unreasonable to use & Reasonable process	L-3 & R-1 & L-2 & R-2

D.Experiment Production

This research focuses on two aiming scenarios: stationary and moving. We recorded reaction times and bullet usage to evaluate performance.

Mission 1: Enemies will respawn at a 45° angle from the player. This tests whether the subjects can make a confirmed hit when the target is at a 45° angle. Five enemies will respawn at each angle, resulting in a total of 20 confirmed hits.

Mission 2: Enemies will respawn at a 45° angle from the player. Two pilot lamps are set up on both sides of the player to test their ability to aim and shoot while walking. There are two walking directions and four shooting directions, resulting in a total of 40 confirmed hits (as shown in Table VI).

The enemy respawn is randomly selected using a pre-set combo. Our research investigates the parameters of market games and records these parameters during the experiment. The experiment is set at 60 FPS and the fire rate, walking speed, and jump/fall speed are created using After Effect. Finally, we define the shot rate as 0.15 2 FPS/sec.

IV. Results

Our research invites 32 subjects (18 male, 14 female) who have no experience in using an arcade stick. They range in age between 19~22 years (20.65 ± 1.0) and are randomly distributed to experimental and control groups. The results are statistic by independent samples t-test.

Tables VII and VIII show that times ($p = .000$, $p < .05$) and bullets ($p = .000$, $p < .05$) are significant. We can see the time cost of L-1 and joystick is 9.92 sec and 25.90 sec. This says the L-1 takes shorter time in the mission. We assume that the joystick cannot aim accurately, and so it is slower. Meanwhile, for the item of bullet use, the L-1 and joystick consume 1.72 and 1.16 bullets, respectively, at the same time. The joystick consumes less bullets than L-1. We assume that the joystick is limited by its function, as the control requires the player to stand still and shoot at horizontal targets. This is why the joystick takes more time to complete the mission.

Times and bullets are also significant ($p = .000$, $p < .05$) in mission 2. The L-1 and joystick times performance are 11.97 sec and 23.75 sec, respectively. After joining the moving action, the times of L-1 are still shorter. However, the imprecise joystick resulted in a longer mission time but it was still shorter than mission 1. Our research assumes that this is because joystick cannot shoot directly at the targets and needs to jump up or down to reach the horizontal platform of targets. Compared to mission 2 which requires repeated shooting at targets along a vertical line, mission 1 requires more time to accomplish. In the bullets item, the L-1 and joystick consume an average of 3.65 and 3.11 bullets, respectively. We assume that the reason is because the joystick is only able to shoot in the orthogonal directions. However, players using the joystick need to intentionally approach the target to shoot. This increases the dead angle despite that less bullets are consumed. And, this increases the chance of being attacked by enemies in the common attack path of scroll shooting games.

TABLE V
MEASURE AND CUSTOMIZE

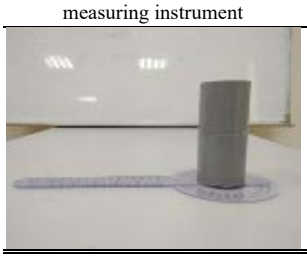
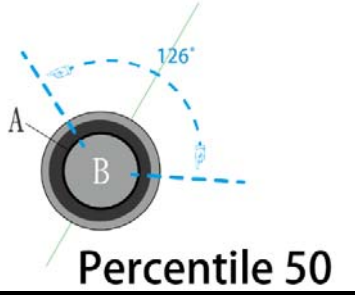
measuring instrument	measure rotate angle
	
L-1 rotate angle	

TABLE VI
MISSION SCENE

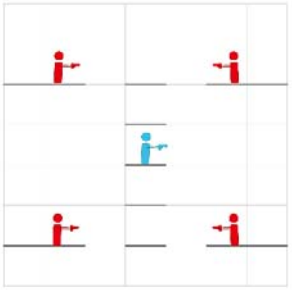
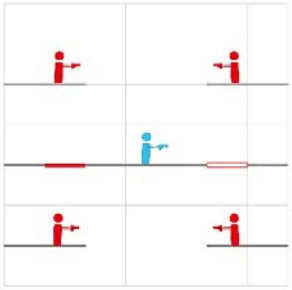
Mission 1	Mission 2
	

TABLE VII
INDEPENDENT SAMPLES TEST

Mission	Index	Levene's Test for Equality of Variances	t-test for Equality of Means
		Sig.	Sig. (2-tailed)
Mission One	Times	.028	.000
	Bullets	.000	.000
Mission Two	Times	.111	.000
	Bullets	.000	.000

V. Conclusion

This research aims to improve the aiming function of the joystick by investigating scroll shooting games and creating the L-1 controller. The joystick is unable to aim precisely despite consuming fewer bullets, putting the player in a dangerous situation, especially in difficult scroll shooting games with many enemies. This often results in a poor game experience for the player.

The L-1 controller's aiming function allows players to complete missions in one-third of the time compared to using a joystick. Although it may consume more bullets, this can be addressed through learning. Our research introduces the L-1 as a controller that is better suited for playing scroll shooting games. However, we did not focus on the whirling angle of the

L-1 and suggest further research in this area, as it may be a point for improving player performance when using the L-1.

TABLE VIII
GROUP STATISTICS

Mission	Team	Index	N	Mean	Std. Deviation
Mission One	Times	L-1	16	8.92	.39
		Joystick	16	25.90	.68
	Bullets	L-1	16	1.72	.23
		Joystick	16	1.16	.06
Mission Two	Times	L-1	16	11.97	.19
		Joystick	16	23.75	1.26
	Bullets	L-1	16	3.65	.14
		Joystick	16	3.11	.06

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