Design Strategy for the Implementation of Cooperative Group Games in Motion Based Arcade Game System

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ABSTRACT

Cooperative Group Games (CGG) emphasize participation, challenges and fun by cooperation among group members rather than competition. CGGs have been proven to be an efficient education method that teaches the value of cultivating cooperation skills, discipline, and sense of public order for tackling problems together through various types of interactions. When integrated with computer game technology, the general classic CGG can be reborn with new educational and entertaining aspects. To combine the joy of physical movement of group games and the richness of computer game contents, a motion based arcade CGG has been developed in this study, based on the original ideas and structures of classic off-line CGGs. While implementing the classic game concepts in arcade environment, various design attributes have been considered and applied, which were supposed to promote cooperative game play. Overall, the process of the implementation and test results of our four CGGs suggest several design strategies for effective arcade CGGs.

Keywords: Cooperative Group Game, Motion-based, Position Tracking, Educational Game, Game for learning, Game for exercise.

1. INTRODUCTION

Gaming has been most natural and fundamental form of human activity long before computer games were introduced. Gaming gives players physical and intelligent motivation as in play and moreover, it is an intensive goal-oriented activity assisted by rules and compensation. When integrated with cooperated work with other players, gaming sets children in educational environments that teach various social skills through communal problem-solving process.

However, the traditional role of gaming in children's play has been rapidly affected by computer game's tremendous commercial success and social phenomenon. In proportion to the pc game's industrial growth, it has been a constant concern that pc games tend to make players socially isolated and physically inactive.

This study is an effort to revive the fun of playing together in classic off-line group games in a modern arcade game environment. In order to combine educational and entertaining benefits of classic cooperative group games (CGG) and technical benefits of computer based games, we developed an arcade game system that allows the player's free movement and rich gaming experience. That is a motion based tracking system in which player's location, as the interface data, is mapped to control immediate response from displayed game contents.

Also, we analyzed the main design features of classic CGG to decide which could be applied to arcade CGG for successful conversion. Most importantly, various design attributes have been considered and applied, which were supposed to promote cooperative game play.

In consequence, four arcade CGGs have been developed and tested with multiple players in public places. The collective results from implementation process and tests indicate several design strategies for designing arcade CGG useful in the computer game era as well as ideas for further improvement.

2. BACKGROUND STUDY

2.1 Educational Benefits of CGG

'Cooperation' motivates us to view the perspective of other people and share our interests to common issues. For example, cooperative study helps students learn the process by studying and solving given problems in a small group[1]-[3]. This idea has recently been applied to games as teaching tools, and resulted in what we call Cooperative Group Games (CGG). It strongly emphasizes cooperation of players on the same team to achieve common game goals. Through team cooperation and competition, we expect players to enhance their skills in personal relations and social interaction.

CGG is not new. Some of the games we participated as children are classic CGG with more emphasis on play than education value. Classic CGG has commonly been used for recreation, physical and social development, and for the energy release that enables children to get back to inactive work at desks. Piaget's research and theory (1932/1965) put emphasis on the educational value of group games for social and moral

development as well as for intellectual and physical development[4].

Specifically, group games promote children's socio-moral development by cooperating and negotiating with partners in order to play fairly as well as their intellectual development by engaging them in opportunities to exercise reasoning and become more logical in thought[5].

Furthermore, group games are related to children's movement and exercise skills, in relation to physical development. The educational benefit of CGG can even be greater with active physical interaction among players since it is known that the development of body and mind is an interconnected process, especially for children[6].

2.2 Technical Benefits of Arcade CGG

A game with a simulated environment is itself a situation where isomorphism between the game and some selected resources, constraints, and goals of a given social situation are carefully established by the designer of game[7]. With its computer graphics display and specially designed devices, arcade games provide 'virtual reality' that offers players an even more enforced sense of virtual presence. It enables the player to fully immerse in game experience.

Arcade games enhance the experience through immersing and realistic means such as specialized featured ambiance or control accessories, including fully enclosed dynamic cabinets, rear-projection displays or highly dedicated controllers etc[8]. However, these accessories are usually too bulky, expensive, and specialized to be used with typical home PCs and consoles. Besides, they are mostly designed only for few users at a time. To accommodate multiple players to play CGG at the same time, restriction on the space by the accessories should be minimized as well as its cost. Arcade games often include very short levels, simple and easy to grasp controllers, iconic characters, and an easy learning curve. These features are also suitable to the design of our CGG, which mainly targets basic team-building experience rather than highly intellectual challenge.

The player gains his virtual presence by association with his avatar, which is the on-screen representation of the player. In order to get an immediate and identifiable response from the avatar, it is necessary to devise interfaces or controllers that do not hinder the player's movement but convey his intention instantaneously.

Overall, the technology and environment of arcade games allow designing a very wide variety of CGG with the assistance of a game interface that transfers the players' individual or group movement to the screen correctly and immediately.

2.3 Related Works

The current trend of promoting the physical benefit as well as educational and social development through computer games has given a birth to motion-based games.

Motion-based games have been devised to provide players with more enhanced feeling of presence and realism in game play, using revolutionary interfaces that reflect and respond to the player's physical movement. In order to minimize the restriction of physical movement for maximizing psychological immersion, hardware design is considered as crucial as software design in motion-based games. Especially for CGG, it is necessary to develop an interface to track the simultaneous motion of multiple players.

There have been several academic experiments with the purpose of developing a motion based game system with a large audience in various public spaces such as a theatre or outdoor area[9]- [11].

Fig. 1. Pong: The collective movement of a large audience controls an onscreen game

Fig. 2. Squidball: a large-scale motion capture based game

These experiments have proven the potential of CGG with a large audience but have also shown problems such as the considerable gap between each individual's participation and interest level as well as unsatisfying game quality and unstable test results when it comes to different numbers of participants.

These problems are mainly related to how to balance the collective purposefulness and individual desire. When tracking a large-scale audience, it is inevitable not to differentiate each player's individual role in the game and this limits the complicity of game contents. On the other hand, production cost will dramatically increase if such a game system employs a technology that tracks each individual separately.

In proportion to the tremendous commercial success of recent motion-based video games like the Nintendo Wii, there has been a growing number of studies focusing on the technologies' potentials to be used for other purposes than entertainment, such as healthcare, surgical training, etc. However, there is still much research to be done for reliable results due to the market's fairly short history. Besides, these have been mainly

designed for home use, targeting a small number of players at a time.

3. DESIGN OF MOTION BASED ARCADE CGG

According to DeVries (1980), who has long studied the educational effects of CGG, there are three criteria in choosing educational group games for children[4]- [6]. First, the game must aim for instant understanding of game flow so that players can judge their success on their own. Second, the game should not be too easy or too difficult for players. If the game's level is higher than the player's, it causes stress. If the level is lower than the player's, it causes boredom. Goal oriented behaviour is determined by the relation between challenges and skill. Third, all players must have roles to participate actively, at least mentally even if not physically, throughout the game.

Based on these criteria, DeVries lists eight general types of games according to their main goals, rules and main activities. Even though we know that there exist many more combinations and variations of the eight types, we relate their general concepts to our eight games by categorising them according to their levels of the two main interactivities, verbal and physical. We define 'Verbal' not as simple auditory inputs but as 'exchanging or formulating complex ideas'.

Table 1. Eight types of classic CGG by DeVries

Types	Game Goal	Verbal Communication	Physical Engagement w/Others
Aiming games	Aim and hit a target with a specially chosen or devised object.	Low	Low
Hiding games	Find an item hidden in a place which is not easy to spot	Low	Low
Racing games	Reach the target area first to win, accomplishing various tasks or in the relay of team members	Low	Vary
Chasing games	Chase and catch another player	Low	High
Guessing games	Guess the answer from limited clues, such as tactual, visual, auditory or verbal information.	Vary	Low
Games involving verbal commands	Accomplish a task guided by other's verbal direction.	High	Vary
Card games	Play cards according to various set of rules	Vary	Low
Board games	Reach a target place or making a certain form by moving counters or pieces on a board according to a set of rules.	Vary	Low

The main activities induced by each type of games are arranged starting with warm-up or ice breaker activities followed by more cooperative group activities for team-building or physical exercise. Warm-up or ice-breaker activities are for team member to feel more comfortable with each other by asking them to find out their team members' personal information or encouraging physical contact while playing games. Therefore, these activities are usually designed to cause very intensive verbal or physical engagement.

Once they burst personal space bubbles, players become more easily cooperative in group games designed for higher intellectual challenge.

Also, players enjoy group games purely designed for physical stimulation for it is related to children's movement and exercise skill in the aspect of physical development.

Fig. 3 The play styles for cooperation in classic off-line CGG

However, in our arcade game, players face front in order to view objects on a projected screen leaving little room to facing team members. Therefore, the games that heavily involves verbal communication such as 'Guessing games' and 'Games involving verbal commands' or the games involving complex physical engagement, which require intensive direct attention to each other, are not suitable to our arcade CGG. This should not rule out the possibility that there is always room for alteration if the peers with whom the players interact are replaced with visual avatars or objects in graphic display so that they do not need to constantly look at each other. Considering different environment and technical factors of arcade game, we list what features of classic CGG should be kept and even more strictly controlled in the computer based game system. For example, classic CGG also needs to control number of players, speed and direction of their movement. In an arcade, it is expected to be more carefully planned due to the limited game space. Furthermore, time limit and score system from classic CGG are to be more strictly and clearly applied with technical and visual enforcement.

Table 2. Features of Classic CGG to be enhanced or altered in Arcade CGG

	Different Factors	Features to be Enhanced or Altered
Classic CGG	Open Space	Basic Game Features: Team, Goal, Rules, Roles of players
	Face to face Interaction	

		ENHANCEMENT ALTERATION
Arcade CGG	Controlled Game Space	Number of players Speed Direction
	Computer Graphic Display	Time limit Score system

Besides, there are features to be fundamentally changed or newly added in the process of conversion. In classic CGG, players move around in relatively open space, physically involved in each other. In contrast, player interaction happens virtually and conceptually through graphic display rather than through direct physical engagement with other players in arcade CGG. It also decreases the room for sharing verbal information among team members, which is often encouraged in classic CGG. Therefore, the direction of game play, such as the explanation of rules, should be as self-explanatory as possible with clear visual and text information on screen. This suggests the typical role of teacher or guide of classic CGG has to be minimized, replaced by a facilitator or operator who runs the game system.

Table 3. Features of Classic CGG to be converted in Arcade CGG

	Different Factors	Features to be Converted			
Classic CGG	Open Space	Teacher/ Guide	(elaborated) Physical Engagement	Verbal Information	Player selves
	Face to Face Interaction				
		CONVERSION			
Arcade CGG	Controlled Game Space	Facilitator/ Operator	(simple or minimum) Physical Contact		
	Computer Graphic Display		Virtual/ Conceptual Engagement	Text/ Visual Information	Avatar Screen Representations

3.1 Design of Game Space

The need to allow players to move freely in the game space without the restraint of body-bind controllers has brought birth to our motion based arcade game system. Generally speaking,

motion based game is designed to give players a sense of reality and immersion in the game by employing an interface that requires and tracks their actual physical movement, thus necessitating special hardware as well as game software[12]. A particular requirement for our CGG is a relatively a large space so the camera-based interface can effectively track the concurrent movement of multiple players.

Based on the discussion above, there are three basic conditions required for a motion based game system for CGG. First and foremost needed is the ability to track the position of all players simultaneously and individually to improve the complexity and quality of the game play and not have team actions based on a "voting average" or "majority" scheme. Second, the hardware interface should not be based on the classic use of confined player hand or foot motions but rather on full body positioning. Third, the game setup must use economically feasible apparatus and facilities to minimize costs.

Table 4. Components of Location-Tracking System

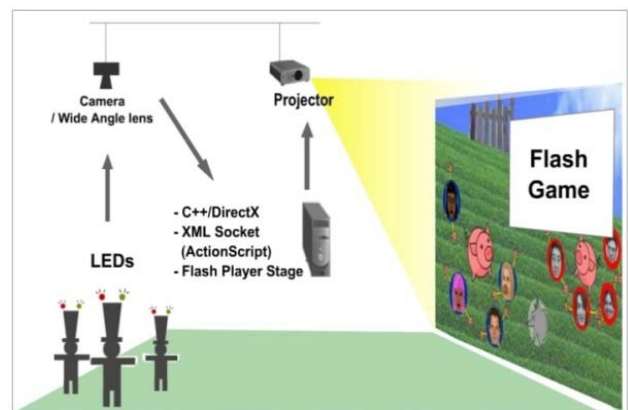| Headset: Hats with a pair of colored super bright LEDs	Can be adjusted to each player's head size so they firmly stay on during active player motion. LED colors are used to uniquely identify each player for tracking his position. The LED has a wide-angle of dispersion so that tracking continues even if a player moves his head from side to side.
Camera	An overhead camera facing downward. With the 4x super-wide-angle lens we attach, we achieve approximately a 25 by 25 feet play area as long as the camera is at least 16 to 18 feet high.
Projector & Screen	A projector behind and a screen in front of the play area. Both must be around 8 feet high so they are not blocked by players. Of course, the play area should be indoor and suitably dark in order to see the screen and to aid in LED tracking (a rare example of reinforcing requirements).
Camera Supporter	Where the camera gets attached and held up, more than 6 meters from the floor.
Computer	Runs games and performs LED tracking
Audio system	Amplify the game audio.

Fig. 4 The hardware structure for motion based arcade game

Fig. 5. The prototype of headsets

Fig. 6. Players and their icons on screen

Fig. 7. Final testing

3.2 Design of Game Contents

Out of the six general types of group games besides 'verbal games', four games for aiming, racing, hiding and chasing, have been developed based on our motion based tracking system. Each of them is expected to perform one of the cooperation patterns 'simultaneous' or 'sequential' in order to see how they affect player performance.

Although we believe that for educational purposes every game should motivate maximum cooperation for best results, each game has various difficulty levels depending on how loosely the concept is applied and how much each individual player is able to make progress for his team without the help from other team members, leading to three scenarios.

The first is that full teamwork is absolutely essential to make any progress towards a team winning the game. The second scenario is that teamwork is strongly encouraged but with the possibility of progress being made to a certain degree by a couple of good players on the same team. The third case is that players are mildly encouraged to play cooperatively as a team-- but also individually--with individual actions having a strong effect on game outcome.

Here are the descriptions of four CGGs we designed based on the above scenarios.

▪ **Firemen game** (Aiming and Racing game)

A big moving fire is in a forest containing several trapped victims. The members of each team can create a water hose by lining up in a straight line, in which case the tip of the spraying water can put out a fire. The members of each team can also move into position around a victim to form a stretcher and carry the victim down to safety out of the fire.

Players can form a water hose or stretcher by narrowing the distance among team members. The game is expected to be an ice-breaker for beginners as a natural way to burst personal space bubbles by promoting touching and hugging.
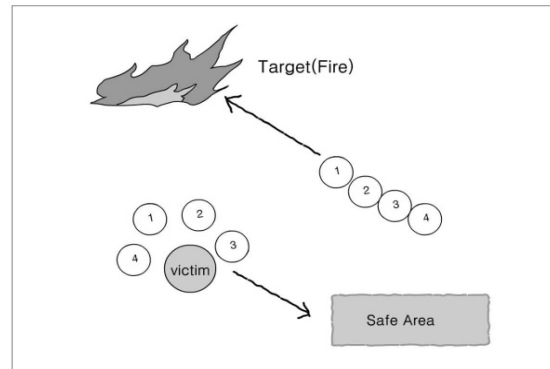

Fig. 8. The game structure and graphic display of Firemen Game

▪ **Carrying game** (Racing game)

Players on the same team can achieve so-called "player-to-player handoffs". In one particular embodiment, players must move food items to the bowls at the top of the screen. After one player picks an item, an on-screen visual progress indicator shows that the player is losing "strength" by shrinking the size of his icon and is about to have the item automatically put down. Before that happens, other players on the same team can note the first player's progress indicator and come over to acquire the item through the player-to-player hand off, thus

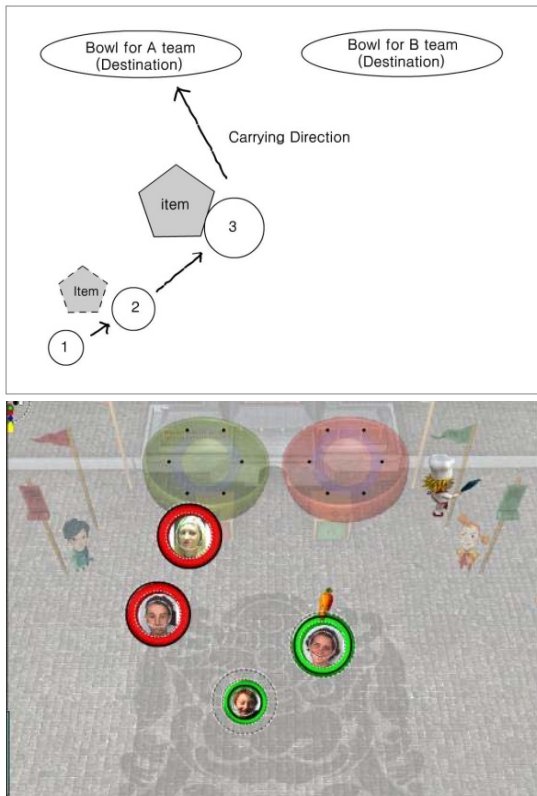preventing players on other teams from being able to acquire the item once it is put down.

Fig. 9. The game structure and graphic display of Carrying Game

▪ **Maze game** (Hiding game-in the sense of finding most appropriate spot, Board game- in the sense of controlling the third object to reach the target area on a board)

A maze tilts in the direction that players stand as a team. Each team rolls a ball through the maze to get the ball out the exit by moving together to spots that appropriately tilt the board. The total sum of weight is defined by the distance of two players so that the players need to keep certain distance between them to form enough force.

The players are only allowed to be around the outside of the maze when controlling it, in order to clear themselves in the way of the ball.
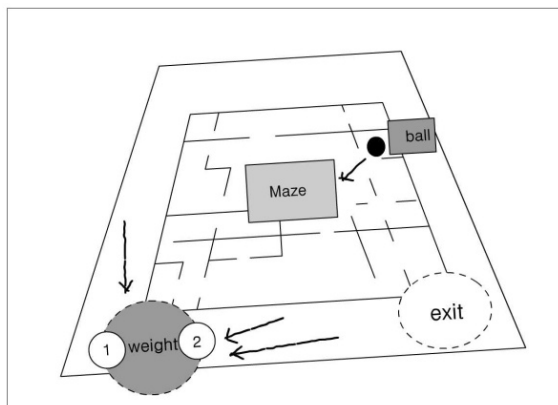

Fig. 10. The game structure and graphic display of Maze Game

▪ **Street-Crossing game** (Chasing game & Aiming game)

There are animated items programmed to follow each player on the side of a highway busy with traffic. The players are supposed to guide the item to cross the highway without being hit by a car. Once the item gets across the road from one side to the other, the team earns points.
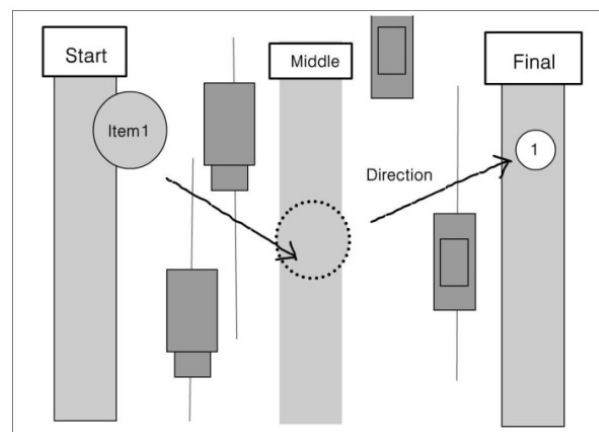

Fig. 11. The game structure and graphic display of Street-crossing Game

Next table shows four main attributes applied for designing the four CGGs. For example, the different patterns of cooperation are intended, whether the players achieve a goal

through simultaneous or sequential cooperation.

Table 5. Different attributes applied in designing four arcade CGG

	Classic Games	Cooperation Level	Cooperation Pattern Simultaneous /Sequential
Firemen	Aiming & Racing	Very High	SM
Carrying	Racing	High	SQ
Maze	Hiding	Mid	SM
Street-Crossing	Chasing & Aiming	Low	SQ

The following additional attributes have been observed and confirmed by test results. Each game has been tested with various numbers of players at a time to find an optimum. These all help define the proper purpose of each game.

Table 6. Additional attributes as test results.

	Individual Play	Physical Activity Level	Optimal Player Number (Player*Team)	Purpose
Firemen	NO	Low	4*2	Ice-breaking
Carrying	NO	Low	(2+)*2	Team-building
Maze	YES	Mid	2*1	Team-building
Street-Crossing	YES	High	(1+)*2	Physical activity

Fig. 12. The play styles for cooperation in Arcade CGG

4. DESIGN STRATEGIES FOR CGG DEVELOPMENT

Based on the successes and failures of repeated trials and follow-up interviews with different groups of players, a set of design strategies emerges for making a CGG more efficient and enjoyable. Game space, cooperation level and the cooperation pattern are the three main factors that influence game flow, playing pattern and interest level.

4.1 Game Space
▪ **Time delay** - The ideal arcade environment is where the players enjoy playing games without feeling physical restriction. The game space we developed has shown some meaningful results and proven the potential benefits of our CGG ideas. However, it has not completely overcome such technical problems as time delay or occasional failure to track an individual player, in responding to the player's speed and location. Players sometimes lost interest in a game when these technical errors occurred and this discouraged their returning to the same game.

▪ **Safety issue and traffic management** - With their eyes fixed upward and frontward onto the screen, players who move with any speed in a limited space can cause safety issues, by bumping into another player or interrupting another's path. Since CGG commonly deal with children, safety issue should always be the top priority. In order to avoid any possible accidents, the games need to be designed with the flow of the players' traffic. In addition, the number of players on each team should be carefully optimized to the requirement of each game, considering speed, direction, time and cooperation level.

▪ **Graphic display** - Visual elements of the games should be designed according to the expected motion path of players in order to avoid excessive traffic. Since players must always watch the projected screen, they always look upward and forward. Thus targets in game display should generally be ahead of the players, which translate to the front of the play area and the top of the screen. For example, in our Carrying Game both target bowls are at the very top of the screen, always in front of both teams. Also, it is good to separate when possible the play space for each team in order to avoid collision of fast players.

▪ **Role of facilitators** – The younger the player is, the more easily he gets attracted to earning scores rather than focusing on how to interact and cooperate with team members. Also, technical errors are fatal in an arcade game. Therefore, the role of the facilitator as well as a technician is still important as a game guide who leads players towards the process of cooperation rather than just winning itself.

4.2 Cooperation Level
▪ **Cooperation** - The games have been designed for different levels of cooperation in order to compare how it affects player performance. In general, the higher the level of player cooperation require, the fewer players move in a "free style" but rather with smaller coordinated and controlled physical motion. This affects the physical activity level and optimal number of players per game.

▪ **Verbal communication and physical engagement** - The

level of verbal communication and physical engagement in classic CGG can reverse in arcade CGG. For example, in classic off-line CGG such as aiming games and hiding games, game play usually happens individually and the collective points of all team members decides the winner. Therefore, the level of verbal communication and physical engagement is relatively low compared to other pattern of CGG. In contrast, an arcade CGG of the same pattern can promote a high level of verbal communication and physical engagement depending on how the means of cooperation has been designed. For example, our Fire game as aiming games shows the highest level of physical engagement of all our games since simultaneous cooperation is essential. The level of verbal communication can also change if a game puts a particular player in charge of verbally guiding other team members to achieve difficult game challenges. However, it may be more desirable for a facilitator to take on this task since it tends to lessen the ability of the player in charge to play and be active. We leave that matter for further research since currently the primary purpose of our implementation has not been intensive educational training but rather basic team-building.

4.3. Cooperation Pattern

▪ **Participation & Individual ability** – Games need to be designed not to be dominated by a few superior or fast-moving players but rather to encourage maximum participation by every player. This further justifies the need to require team cooperation, while balancing against the extra scoring incentives needed to keep skillful players interested in the game.

By the same token, the degree and purpose of cooperation are desired to be flexible according to players' different physical and intellectual ability. When playing games for simultaneous cooperation, players move together but their contribution can differ depending on each individual. In this case, the solution is to give them slightly different roles in which to contribute. In performing sequential cooperation, it is sometimes necessary to control players who dominate the entire game flow by limiting the time that they can "hog" the game play. In general, 'sequential' cooperation has more flexibility in that matter. For example, when agreed, our two sequential 'Carrying' and 'Street-crossing' games allow a fast player to earn extra scores by moving individually and repeatedly in a given time.

Nevertheless, it is unavoidable that the more players involved in this, the simpler and more standardized the rules and purpose of the game become.

▪ **Physical activity level -** Unlike 'physical engagement', physical activity level indicates the level of physical stimulation occurring to players during game play. It is correlated to 'cooperation level' and 'player numbers' in our four CGGs since they decide how freely the players move in the play area. The amount of physical activity in the 'Street-crossing game' that allows individual play is considerably higher than that of the 'Firemen game', that requires intensive team-work of all members. For safety issues though, it is desirable that the natural game flow cause each player to subconsciously keep himself in separate zones from other players and be active inside the zone for maximum physical stimulation.

4.4 Purposes of Games

Physical engagement, cooperation level, individual play, physical activity level and intellectual challenge all contribute to define the purpose of our CGGs. Our 'Firemen game' is suitable for 'ice-breaking' for its easy game rule and physical engagement. On the other hand, our 'Street-crossing game' is our most competitive individual game suitable for physical activity. The other two games should be used for actual team-building since they require a relatively advanced level of cooperation among team members.

5. CONCLUSION

Considering the purpose of CGG and the production cost, we have developed a motion based tracking system comprised of simple and accessible input and output devices. Game content partially originates from the ideas of classic CGG but is heavily conditioned by the technical and physical game environment.

As the final outcome, four arcade CGGs have been developed with different cooperation levels and patterns. During the tests with different groups of players in various public places, we observed several design factors that affect game flow and player playing patterns, regardless of the designer's original intentions.

Although this paper is limited to suggesting a prototype implementation of CGGs in an arcade environment, it will continue to be enhanced by more elaborate game design and tests with various player groups. In order to carry it out beyond the bounds of in-lab experiments, it is important to make players return to play again by keeping a balance between the intellectual level and cooperation level of the game. If one outbalances the other, the game might be boring or meaningless. An effort to fine-tune both features as well as further work on our technical challenges will continue in future efforts aimed at wide spread usage of our CGG.

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