Introducing Shared Character Control to Existing Video Games

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ABSTRACT

Many people enjoy the social aspects of gaming, but most video games are designed to be played by only one person at a time. We introduce WeGame, a system that increases the sociability of single-player video games by allowing joint co-located play. The WeGame mediation framework flexibly merges the inputs of multiple players into a single control stream before forwarding it to the gaming system in real-time, and supports visual overlays to give players feedback on the newly-injected social dimensions of the game. Studies with more than 50 participants explore the new space enabled by WeGame, showing the social and preferential effects of several archetype mediation strategies. The WeGame approach has the potential to improve the social aspects of existing single-player games, allow novices to learn from experts while playing together simultaneously, and improve gaming performance.

Keywords

Video Games, Collaboration, Cooperation, Social, Multi-Player Games, Shared Control

Categories and Subject Descriptors

K.8.0 [**General**]: Games; H.5.3 [**Group and Organization Interfaces**]: Collaborative computing

1. INTRODUCTION

Many people enjoy playing video games with others as a co-located social activity, but the number of games that are designed for co-located group play has, for the most part, been decreasing since 2006 [12]. People often use workarounds, e.g. trading off the controller among individuals in the group, but these methods are cumbersome and leave most players idle at any one time. Games designed for multiple players increasingly require participants to use separate gaming systems, which encourages remote synchronous play[1], despite co-location generally affording a better multiplayer experience [7]. Multiplayer games, such as World of Warcraft (Blizzard Entertainment, 2004) and Rockband (Harmonix Music Systems, 2007), generally expose a shared virtual playing field in which each player controls his or her own individual character. In this paper, we introduce WeGame, which takes a different approach to supporting co-located group play by allowing multiple players to jointly control a single character in existing games.

When using WeGame, players issue commands to a single in-game character. A mediation layer captures and selectively forwards these commands to the game. A primary challenge for WeGame is that the games it targets are not explicitly designed for group play, and so naive approaches to adding group control lack many of the qualities comprising good game design. For example, with multiple players trying to simultaneously control the same character, players may not receive adequate feedback on the results of their actions. To address this, we added a visual overlay for feedback (Figure 1). Thus, within the WeGame framework, creating gameplay experiences that are enjoyable and that encourage social interaction is dependent on the design of the mediators and visual overlays.

When players want to make single-player games more social, they often share controllers with friends. This physical hand-off interrupts game flow and makes close collaboration difficult, which may explain why it is most often reserved for natural breaking points in the game. For instance, nearly half of players in our study used failure as a trigger for passing the controller. In addition, handing off the controller does not keep all players equally engaged since only one player can actively play, while the rest are limited to speculation and commentary. To surpass this limitation, WeGame eliminates physical hand-off and automates turn-taking in one mode, and facilitates collaborative control of single player games from multiple controllers simultaneously in another. Thus, players can enjoy co-located collaborative play without encountering unnecessary breaks in flow and without purchasing special hardware.

[1]LAN parties bring players together but require substantial effort.

Figure 1: An example of 4 players simultaneously controlling Half-Life 2, a first person shooter, in single-player story mode.

To explore the new space enabled by WeGame for existing games, we iteratively designed and implemented several archetype input mediators and visual overlays. The mediators we developed allow multiple players to share control of an in-game character in ways not previously supported by the game. Different mediators allow the group to: *(i)* collectively control all aspects of a character, *(ii)* split control of specific features between players, e.g. moving and shooting, *(iii)* trade off control at fixed intervals or randomly in order to keep everyone engaged, and to *(iv)* serve different roles, e.g. a standard player and an advisor who is given a cursor overlay to point out on-screen elements that might be important.

A formative study of WeGame considered four mediators modeled on the existing concept of handing off controllers in order to allow multiple co-located players to share control of a single-player game. This model "forced" everyone to play and increased social activity while playing the game, but highlighted the known problem of player groups with members of varying skill levels. Namely, experienced players felt as though they were being held back by weaker players, and weaker players felt uncomfortable contributing because they might "mess up." Based on these results, we designed new mediators that encouraged everyone to contribute but did not tie overall performance to the weakest player. These mediators stressed collective control, eliding each individual's performance into the collective to reduce anxiety. A summative study showed that these mediators encouraged group participation while adding enjoyment via social interaction. In longer trials, participants not only became better at the game, but also showed improvement in working together within the framework of WeGame. They came to see WeGame as a meta-game that they could play together in the context of the original game they were playing.

The primary contributions of this paper are: *(i)* we introduce WeGame to improve upon the common approach of turn-taking (passing the controller) for multiple players interacting with a single-player game, *(ii)* we present a formative study that explores the space of shared control in existing video games enabled by WeGame, and *(iii)* we discuss how collaborative control may help players learn from one another, play better than any individual alone, and allow for seamless player substitutions.

2. BACKGROUND

WeGame builds from work in *(i)* multiplayer gaming and *(ii)* shared control of games and other user interfaces.

2.1 Multiplayer Gaming

WeGame transforms single-player games into multiplayer games, so our expectations of how will work can be informed by looking at analyses of current multiplayer games. McClintock [18] outlines several kinds of social motives, which map to different types of multiplayer play. During *competitive* play, each player aims to maximize his or her own standing in the game relative to other players. This format is slightly different from *individualistic* play, where players maximize their own standing regardless of others. A third form is *cooperative play*, in which players maximize their own standing by maximizing the standing of others, although cooperative games might still have an element of competition, such as individual score. WeGame is primarily a cooperative game, in which player interests always align and the incentive to do well is derived from social incentives to perform well in front of peers.

WeGame can also support other kinds of play depending on the mediators and overlays that are designed. For instance, McClintock discusses *altruism* as another incentive for playing, in which people are motivated by their desire to maximize the standing of others. WeGame supports altruism by allowing players to helpfully point out on-screen items to others. WeGame can support competition incentives by displaying metrics related to whose input the system tends to favor listening to, even during cooperative control. Because WeGame is assumed not to have access to the internals of the games on which it can run, it does not support individual performance metrics based on how well players are doing within the game. Future versions may use techniques like optical character recognition (OCR) [5] to track point acquisition and assign points to players most responsible for control at the time.

2.1.1 Multiplayer Experiences

Substantial work has been done on how to create compelling cooperative and collaborative games. WeGame does not enforce these design elements in its framework, but is flexible enough to allow mediator and overlay designers to include them. Rocha *et al.* describe a number of common design patterns for cooperative games useful in designing WeGame mediators [22]. For instance, WeGame subscribes to the "Shared Goals" pattern by putting players in control of the same in-game character, which we assume has a goal prescribed by the original single-player game. In addition, mediators that divide control of different functionality between players exhibit the "Complementary" design pattern, in which players have different abilities that support one another.

Zagal *et al.* [23] developed lessons and pitfalls from the collaborative board game Lord of the Rings (Reiner Knizia, 2000) that informed the design of WeGame. For example, visualization of player input disambiguates the connection between decisions and payoffs. In addition, the researchers noted the importance of allowing individual players to act without group consent, which WeGame permits because mediators do not necessarily require group approval to forward actions. WeGame's support for "Complementary" play allows mediators to avoid the pitfall in which one player could control everything. Creating compelling experiences within WeGame is interesting because designers are not in complete control of all gameplay, but must instead work with the constraints of existing games. One result is that different mediator and overlay combinations may be more appropriate for different game types.

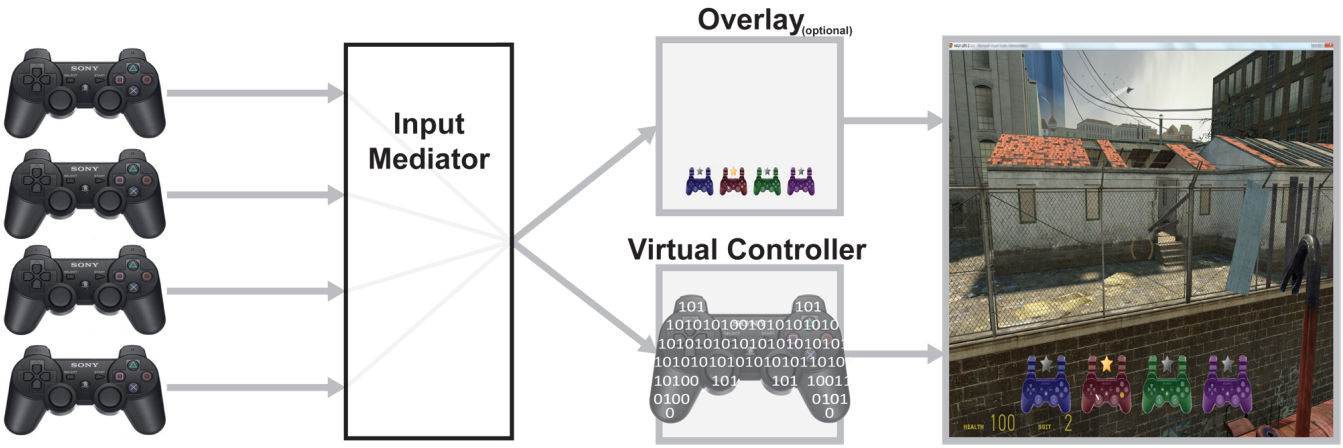

Figure 2: In WeGame, input from each player's controller is passed to an input mediator that selectively forwards input to both an on-screen visual overlay and a virtual controller that issues commands to the underlying (off-the-shelf) video game.

2.1.2 Shared Characters

El-Nasr *et al.* [6] explored the potential for shared characters by observing children play Lego Star Wars (Traveller's Tales, 2005). In Lego Star Wars, players can switch between which character they control, as long as the target character is not already in use by another player. In combined results from observing kids playing Lego Star Wars, Rockband (Harmonix Music Systems, 2007), Kameo (Rare, 2005), and Little Big Planet (Media Molecule, 2008), El-Nasr *et al.* found that a shared character led to 11.4% of instances of laughter and excitement together, 8.1% of instances of working out strategies, and a large portion of instances of global strategies, in which each player took on a particular role to work together. Although WeGame supports more complex mediators than Lego Star Wars, these results imply that even simple player sharing of an avatar can have a positive impact on the group's enjoyment level.

2.2 Shared Control in Games and Other UIs

Prior work has considered shared control in both games and other user interfaces. Some researchers have studied collaborative control with large audiences [3, 4, 17], while others have focused on shared control in the classroom [2, 19, 20, 21]. Inkpen *et al.* [11] explored shared control of a single-player game by having pairs of children share a computer and mouse. Sharing a single input device caused conflict among the participants as they fought for control, especially in Male/Male pairs. In later work, children played a game together with either one or two mice [10] and utilized the two control-sharing protocols *Give* and *Take* when using multiple mice. Give required one player to give control to the other player, whereas Take allowed either player to take control whenever the player wanted. WeGame explores a richer space of mediators. In addition to supporting the original Give and Take control schemes, WeGame allows all players to collectively control a game character at once and even distribute different subsets of control.

Split control of an avatar has been used in existing games. For instance, Perfect Dark (Rare, 2000) allows two players to control avatars according to four preset control configurations. For the Global Game Jam 2012 (globalgamejam.org), participants formed teams and created games based on several constraints. One optional constraint was to have at least three people control a single avatar. Most games that used this constraint required each player to control a subset of avatar actions. One game used input summation, and one based actions on the number of votes for every four second window. With WeGame, players share control of a single avatar with the option of delegating different in-game actions among players.

2.2.1 Small Group Control

Prior systems have also allowed for joint control in non-game domains. For instance, Goldberg *et al.* [8] introduced the idea of a Multiple Operator Single Robot (MOSR) system, in which multiple people control a single robot. They instructed a group of users to maneuver a Ouija pointer through a two-dimensional maze via a robot arm. Users conveyed desired force through mouse movement, and their inputs were averaged to determine the resultant action. People were able to complete the maze faster when working together than on their own. Goldberg *et al.* [9] later created a more advanced MOSR in which users controlled a tele-actor that responded to input in real-time. Mouse clicks were interpreted using a clustering algorithm. WeGame has several alternative control schemes, which explore more complex kinds of interaction.

Lasecki *et al.* [15] introduced Legion, a system which allows *the crowd*, remote groups of anonymous web-workers, to control existing user interfaces by forwarding workers' mouse and keyboard input to an *input mediator*. The mediator merges the inputs into a single control stream and sends it back to the interface. Legion was used to navigate an off-the-shelf robot through a maze, control a spreadsheet program, create a crowd-powered assistive keyboard, and perform other interface control tasks. Legion's control schemes include serialization and weighing inputs based on past performance. In order to ensure reliable responses, the Legion *leader* input mediator found the worker who most closely agreed with the majority overall by calculating the vector cosine agreement of individual workers compared to the group using:

$$VC(a_i, c) = \frac{a_i \cdot c}{||a_i|| * ||c||} \quad (1)$$

This score was then used to update worker weights using the following formula:

$$w_i^{(t+1)} = \alpha w_i^{(t)} + (1 - \alpha) VC(a_i^{(t)}, c) \quad (2)$$

where $\alpha < 1$ is a discount factor.

At each small time step (approximately 1 second) the worker with the highest weight was chosen as the leader and given control for the next time step.

Unlike Legion, where crowds were anonymously recruited from crowdsourcing marketplaces such as Amazon's Mechanical Turk and no explicit means of player communication were provided, WeGame is geared towards small groups of intrinsically motivated players that often know one another and are able to collaborate in person. As a result, the group dynamics differ in ways that affect collaborative control, and thus change the design parameters for WeGame. Specifically, in WeGame, players can easily communicate with one another about strategies and goals, and malicious players are less of a problem because the group can recognize and choose how to deal with them.

2.2.2 *Large-Scale Shared Control*

Massively Multiplayer Pong [1] allowed a large group of co-located players, such as a room full of conference attendees to collectively control the paddles in a game of Pong. This game uses simple averaging, along with a visualization of individual player positions, to aggregate the input of multiple people. Since Pong involves only a single axis of motion in a continuous space, this approach fit the specific game well.

More recently, the game Twitch Plays Pokémon went live on the video streaming website Twitch[2]. The website streams a running game of Pokémon Red (Game Freak, 1996), an old single-player turn-based role playing game. To interact with the game, viewers enter commands into the video's chat window. The commands are then forwarded to the game. Twitch Plays Pokémon's popularity has led to over 100,000 simultaneous players[3], and from the chaos have emerged additional game rules to mitigate some of the associated issues. The most relevant change has been the addition of a democracy mediator, which forwards the most popular input choice for every 20 second time slice. By creating this voting system, the developer was able to remove some of the randomness that prevented progress. Players can switch between modes by voting in the same way as for game input. Although WeGame is designed for small co-located groups, we discovered the importance of creating such a time slice based mediator of our own.

3. WEGAME

WeGame is implemented as a service-level program for the Microsoft Windows operating system. It captures the input from multiple controllers, and selectively forwards it to an original game via a virtual input device, and updates a visual overlay. Player input is captured in *input cycles*; each cycle holds information about the most current controller state for every player. It is sent to a mediator that determines what input should continue on to the game based on a set of rules provided by a designer. The mediator passes along input and information on who has control to an overlay program that provides visual feedback. The mediator output is also passed to a virtual controller that uses *vmulti* (code.google.com/p/vmulti) to send the input to the game (Figure 2).

3.0.3 *Input Mediators*

The input mediators determine how user input is collected and selectively forwarded on. For the initial system, we chose to implement four simple mediators inspired by the way players currently share control in single-player games: handing around a single controller. In later iterations discussed in the following sections, we used the experience from these early mediators to design mediators that move away from the concept of sequential control. Our initial mediators are as follows:

Figure 3: WeGame's five control sets: directions (red), actions (green), alternates (yellow), analog sticks (blue/purple).

- **Sequence** virtually passes the controller automatically in a fixed order every 10 seconds (a value determined to be sufficient through play tests). The relatively short interval keeps players involved and attentive because, even with a group of four, their off-period will be at most 30 seconds.
- **Random- 10 Seconds** adds unpredictability to Sequence by using a *random* order, with the goal of increasing players' engagement. Initial play tests showed the 10 second interval worked well for players who preferred a faster pace.
- **Random- 30 Seconds** increases the time between random automatic controller passes to 30 seconds. The result is that each players is given a bit longer to play the game and accomplish something.
- **Multi** forwards all players' input to create a single control stream from the group. A similar mediator was shown effective at continuous control and navigation tasks in [15]. This mediator represents the limit of how fast the controller could be passed (if you press an input, you have control), although coordination may be difficult because the mediator does not show which player is currently in control. To avoid jitter from disagreement, WeGame uses a sampling rate of 100ms.

These mediators vary on player engagement, level of predictability, and control sharing. All mediators work with any number of players, each with their own controller. Players were able to observe their controller input via an overlaid UI (Figure 2). For turn-based mediators, a star was shown above the controlling player's controller on the overlay. As this player's turn progresses, the star "drains" to reflect how much time the player has left.

[2]http://www.twitch.tv/twitchplayspokemon
[3]http://blog.twitch.tv/2014/02/recent-chat-issues-and-twitchplayspokemon/

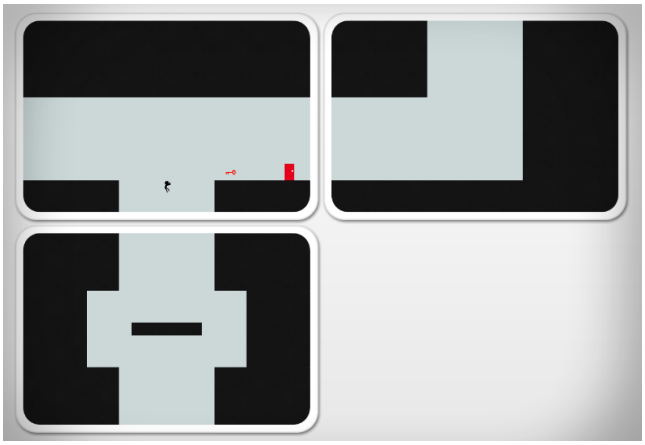

Figure 4: Continuity, a puzzle game played by WeGame study participants. Players must slide the 3 pieces of the map into various orders to allow them to reach the exit of the level.

Figure 5: Ys Origin, an action-adventure game played by WeGame study participants. Players move around large open-ended maps and fight enemies while trying to trying to find certain objects needed to progress.

3.1 Formative Evaluation

We conducted a formative study of WeGame using this first set of mediators to better understand how they compared with one another and with manually passing the controller. Four-player teams each played Half-Life 2 (Valve, 2004), a popular first-person shooter that includes many common game elements, such as puzzles and platforming. Our study consisted of 24 players (14 male), ranging in age from 18 to 29 (mean 20.5). Experience with console shooters ranged from rarely playing games to playing games more than 10 hours per week. Because groups were randomly assigned, familiarity with fellow group members varied. We used Sony PlayStation 3 controllers, a desktop PC, and a 42" television, with players seated next to each other on a couch. Participants played this game collectively using the four mediators described above and in a control condition in which they passed the controller among themselves. To avoid bias, the conditions were randomized. Segments were sequential and progressed in difficulty as part of the game.

When each team started, they were asked to develop their own strategy for trading off control of the game. In all cases, trading control was done at some sort of in-game "event," e.g. when the player's character died or completed a level. Sometimes, control was traded in order to tap into expertise, e.g. a novice player may ask a more experienced player to take over at a difficult point in the game. Relatedly, sometimes control was traded to allow players to play portions of the game they found interesting or hadn't previously been able to play. Players' control lasted an average of a minute or more.

The mediators that forced controller changes unsurprisingly increased the rate at which control changes occurred. The mediators that randomly changed who was given control were disliked because the hand-off was difficult for players to successfully execute. There was often a long pause while the group waited for the next player to figure out that he or she was in control and begin playing.

Players who rated themselves as novices were more likely to mention that they felt scrutiny during turn-based play. Some of these players felt they were holding the group back by being forced to contribute equally. Some players preferred to contribute suggestions, rather than actively control the avatar. These players would often help the controlling player by pointing out in-game objects, helping to solve puzzles, and suggesting a course of action. These *passive contributors* differ from people who play a strictly observational role, since they provide constructive input.

We observed that players with a higher *perceived* skill level were often overbearing, and negatively impacted other players by being demanding and even ignoring or arguing with others' suggestions. Many players noticed a lack of input feedback in Multi. Initially, we visualized input on-screen (Figure 2), but found that overbearing players used it to single out players who were not contributing (which slowed progress). One novice user said this scrutiny from other players caused additional stress.

When using Multi, 6 out of 24 players independently commented that allowing for divisible independent control of a character was a missing key element. For instance, several participants noted that they thought it might be a good idea if players were able to control different functions of the character at the same time; One player could move the character around in the virtual world, while another aimed and shot at enemies.

3.2 Changes Following Formative Study

Following our exploratory study, we made a number of changes to WeGame. First, we added support for passive contributors by adding *command mode*. In this mode, players are identified by color and can: *(i)* indicate visually a general direction via arrows that appear on-screen, or *(ii)* toggle a dot or ring shaped cursor that can be moved, highlighted, and resized on-screen, independent of the game. Communication support for inactive players has been implemented in several games, including Valve's cooperative two-player game Portal 2 (Valve, 2011), where players can gesture, take on their partner's view, set a marker at a location, and start a shared timer, as well as traditional verbal and text-based chat. Nintendo's Wii U gamepad (nintendo.com/wiu) can allow a player to take on a support role while others play a more traditional active role.

In our initial design, we had one naive method of simultaneous control (Multi). We developed the *Legion Leader* mediator inspired by the Legion system [15] to allow for better collective control through the election of leaders who assume temporary control. In this mediator, the more a player agrees with co-players, the

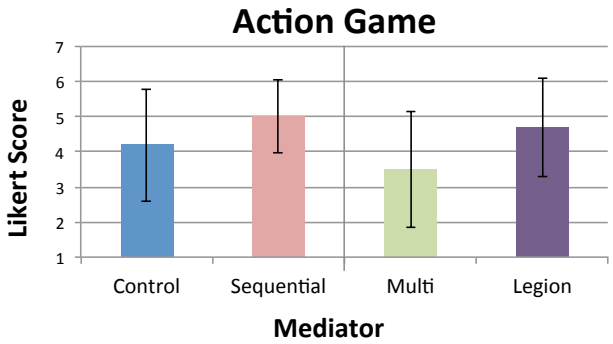

Figure 6: Likert score ratings per input mediator condition for the action game *Ys Origin*. Both the Sequential and Legion input mediators were rated significantly better than their naive counterparts Control and Multi, respectively.

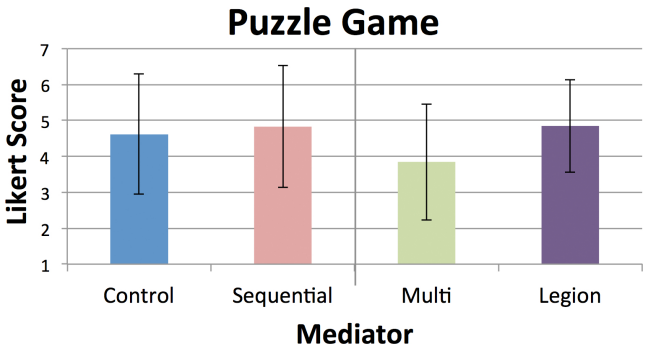

Figure 7: Likert score ratings per input mediator condition for the puzzle game *Continuity*. The Legion mediator was rated significantly better than its naive counterpart Multi.

higher the player's weight. Every 100ms, we recalculate weight and determine a potentially new leader, who has exclusive control of the game. Change in leadership is gradual because weight shifts slowly. We chose to replace Random with Legion Leader in our next iteration because it combines the idea of trading off control while allowing all players to contribute.

To address the players' desire to divide control, we added the ability to control different sets of input separately from one another (Figure 3). For each subset of controls, all active players who want to contribute are merged together based on agreement, while players who are inactive for that subset are not considered. For example, two players can focus on controlling movement with the left analog stick, while two others focus on looking around with the right analog stick. This also addresses the players' interest in being able to pause or temporarily not contribute.

4. EVALUATION

Our evaluation consisted of two components: *(i)* a large study of controlled group play for two game genres across four mediator conditions, and *(ii)* a smaller study of extended play using Legion Leader, the mediator found to be most popular for the action game.

4.1 Study of Controlled Play

For this study, we use the puzzle game *Continuity* (Figure 4) and the action game *Ys Origin* (Figure 5) as archetypes of these genres. Our trials involved 26 participants (21 male) playing in groups of three or four. Participant ages ranged from 19 to 30 with a mean age of 23. Playing habits ranged from rarely playing games to playing games more than 10 hours per week. The physical setup of our experiment was identical to our formative study. The play session was split into 8 blocks, each 5 minutes long. We used one game for the first 4 blocks, and the other for the remaining 4, randomizing order. For each game, players played one block for each of the following mediators: Multi, Sequence, and Legion Leader, as well as one block as a control (randomized order). As before, in the control block, participants decided among themselves how best to share control using a single controller. At the start of each session, they were told that verbal collaboration was encouraged, and at the start of each block, we provided a high-level explanation of the relevant mediator. At the start of the first block with a command mode option, players were instructed on how to use it and given an opportunity to interact with the system until they felt comfortable.

4.1.1 Results

Following each block, participants rated how much they liked the mediator used in the previous round on a 7-point Likert scale. We used the Wilcoxon signed-rank test to compare pairs of mediators for each game. The control scored significantly lower than Sequence for the action game ($z = -2.02$, $p < 0.05$). For action games, which require a high level of focus and quick reflexes, Sequence seemed to improve the gaming experience by lowering the interruption that occurs during control passing. Such a significant disparity did not exist for the puzzle game, although on average Sequence (mean = 4.8) faired better than the control ($\mu = 4.62$). This result is most likely due to the nature of puzzle games; the focus is on cognitive effort and group deliberation, rather than the execution of puzzle solutions. Player preference for Sequence over the control suggests that WeGame provides a better multiplayer experience than playing the game as designed in a co-located multiplayer context. Multi faired significantly worse than Legion Leader in both the action game ($z = -2.94$, $p < 0.01$) and the puzzle game ($z = -2.39$, $p < 0.05$). One factor that may have contributed to this disparity is in-game thrashing caused by conflicting players' input being forwarded to the game.

We polled players to gauge whether WeGame increased interaction with co-players when playing single-player games. Players reported an average score of 5.7 (SD=1.0) for the statement, "WeGame increased my interaction with fellow players." One player compared WeGame to traditional controller passing, saying *'playing action games together is more fun than one person watching.'* When asked what they liked about WeGame, another said *'The fact that everyone was involved (especially in the puzzle solving game).'*

Many players chose to take advantage of Command mode, even though they were not required to do so. When asked to rate its usefulness on a 7 point Likert scale, through the Wilcoxon signed-rank test we found that players found it to be significantly more helpful for the puzzle game ($\mu = 5.0$) than the action game ($\mu = 3.08$), ($z = -3.58$, $p < 0.01$). As players explained, *'It helped bring attention to things'* and *'Command mode was helpful doing the puzzle game where specific direction was necessary.'* Those that chose to ignore the feature blamed its 'redundant' nature since verbal input was more convenient to use. Some of the negative opinions of Command mode seemed to stem from a perception that it was too clunky and complex in its current implementation. One problem is that we used linear gain on mouse movements, which made it difficult for players to move swiftly across the screen while still making fine local motions.

Eight players mentioned having trouble noticing the start of their turn when using Sequence. Although we show a draining star on screen and in our original version even flashed the color-coded text 'Player X' at the top of the screen, players did not seem to notice the cue. Players made several suggestions including vibration and sound effects. A potential problem with these indicators is that they can get annoying over time. One player suggested a hybrid of Sequence and Legion that would gradually transition from one player to the next over a few seconds to avoid abrupt changes. This suggestion is especially enticing because it combines turn-based and many-as-one gaming. When players noticed their turn was ending as they were about to perform an action that requires precision, they sometimes chose to instead wait and let the next player do it so that the control shift did not occur mid-activity. Weighted control between turns could make the transition between players less abrupt, and therefore may prevent this hesitation.

We found that some groups took advantage of split control, but only in the action game. Several participants avoided this feature because there were not enough controls for everyone to actively participate. As one player pointed out about the puzzle game, *'Jumping and moving in platforming games...they're all one motion,'* while another explained that *'The action game for me was just a bit more complicated. ... They could focus on attacking and jumping and ... I could just hold the button so that we can move faster.'* These statements suggest that split control may be more appropriate for games with distinct sets of possible actions.

4.2 Extended Play

Natural play times are generally much longer than the controlled blocks in our first experiments. Therefore, we had four casual gamers use Legion Leader, the most popular mediator for simultaneous control, play three games: the action/adventure game *The Adventures of Dear Explorer*, the platforming game *Exit Path* (Figure 8), and the first-person shooter *Bulletstorm*. We chose these more action and precision-oriented games because we wanted to see if performance issues stemming from our system are mitigated over time as players get used to the mediator. We suggested that players spend 20 minutes on each game, although they were allowed to stop playing at any time or continue playing for longer, which they did.

When playing the platforming game, players commented that *'it was fun even if we didn't do well,'* and in fact *'we played better than I do alone.'* They were surprised at how far they got in the game. Here we can see that although high-precision can be hard to coordinate with simultaneous control, people still felt that the group did better than the individual. Part of this success may be due to the fact that *'it isn't as frustrating to die because you can just let go for a moment and keep watching your character try.'* Players could hand off control if they felt that they were negatively impacting precision and jump back into the game very quickly once the rest of the group completed that portion of the level.

When playing the shooter game, we asked players to try splitting up controls. One player explained that *'I think splitting up the controls worked better,'* referring to how it worked better in the shooter game than in some of the others he had tried. The players designated responsibilities, but contributed to other players' commands from time to time.

Players adapted their strategy to our system. At one point when players got stuck, one suggested that the group should let a single person control the game for the difficult section. Upon success, the group resumed playing without having to consult each other about control. Over time, additional adaptations may occur as players become more familiar with WeGame. While we started with the idea that WeGame would improve players' abilities or enjoyment in terms of the existing game, it may be that the more interesting aspect to consider is the meta-game and coordination created by WeGame itself.

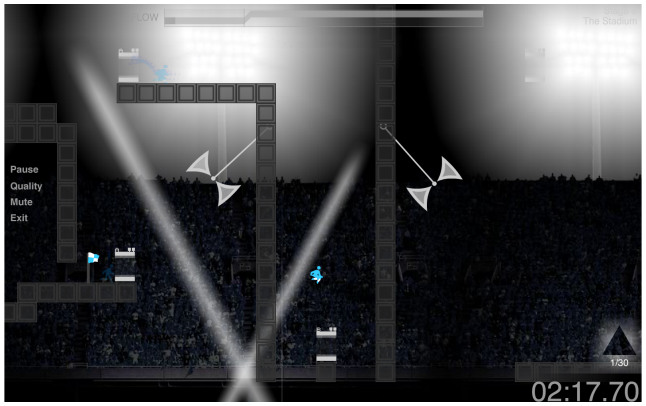

Figure 8: Exit Path, a fast-paced Flash game that we used as part of our extended play tests. Players are asked to navigate a series of obstacles as fast as possible. Coming in contact with one of the hazards will reset the players' location to a previous point to try again. Despite these challenges, our players found the game enjoyable once they coordinated their actions.

One long-term effect that we were unable to catch within our 20 minute trials is whether players learn everyone's strengths as they play. Such knowledge can be used not only to determine who takes over when facing certain types of challenges, but also for responsibility delegation for split control.

5. FUTURE WORK

In this paper, we introduced WeGame, a system that injects collective control into existing video games. We believe WeGame opens a new space of social play on top of single-player games, which represents interesting new challenges for future work in designing compelling experiences within the constraints of existing games. Through the development and study of several archetype input mediators and visual overlays, we started to explore this rich space.

5.1 Interface and Functionality Enhancements

Command mode can enhance player to player communication via on-screen visual cues that were easily understood. Future work will explore new types of overlaid feedback and will further support for the extension of existing roles.

We will also explore how players choose to customize their controls, both in terms of the control selection interface and personal preferences. In addition, we are interested in long-term effects, such as how players might learn new techniques and acclimate to gameplay using WeGame. This can also lead to approaches for *synthesizing* input in real-time rather than just selecting from it [13] to support motor impaired gamers who could not otherwise control an off-the-shelf game independently. Prior work has shown that this type of input synthesis can even yield workflows that reduce the level of motor skill required to effectively contribute to a task [14].

5.2 Helping New Players Learn

By allowing novices and experts to collaborate, WeGame may have implications for education. Members of a group might implicitly learn from the actions of the collective [16], suggesting that WeGame could possibly facilitate in-game learning without impeding experienced players. In addition, experts could play a support role by seamlessly taking over partial or full control while a novice progresses through a game, such as a child playing with a parent or a novice player playing with the help of an expert friend.

In the future, we will explore how split control may allow novice users to master one action or set of actions at a time. Our approach may also extend beyond co-located gaming to inform other collective control tasks, such as robot guidance or even remote surgery.

6. CONCLUSION

WeGame provides a framework to allow a group to play existing single-player games more socially. When using WeGame, all players have an individual controller, but share control of the same in-game character. Across several studies, participants found the mediators provided by WeGame preferable to sharing a physical controller, and in an extended study, players felt that WeGame actually improved the games they were playing.

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