Chapter 2
Games in General

You've spent all your life learning games; there can't be a rule, move, concept or idea… that you haven't encountered ten times before.

Iain M. Banks, *Player of Games*

Abstract Combinatorial games make an ideal test bed for the Ludi project as they typically involve simple, well-defined rule sets but complex play. A simple *means-play-ends* model of game play is presented, then combinatorial games and the elements or *ludemes* that make them up are described in this context. While it is simple to recombine the elements of a game into novel configurations that define new games, it is much more difficult to identify those that actually produce a good result. This chapter describes some of the factors involved and how to distinguish new games from mere variants.

Keywords Combinatorial game · Ludeme · Game design · Recombination game · Game variant · Game distance

2.1 Defining Games

Of the many ways to define a game, Salen and Zimmerman [51] make the following useful observation:

> A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome (p 81).

This definition was condensed from the findings of many prior studies, most of which identified rules, play and outcome as the key elements of a game.

This suggests the basic game model shown in Fig. 2.1, which consists of:

- *Means*: The equipment and rules for playing the game.
- *Play*: The interaction between the players, defined implicitly by the plans they devise and explicitly by the moves they make.
- *Ends*: The resulting outcomes that these moves produce.

C. Browne, *Evolutionary Game Design*, SpringerBriefs in Computer Science,
DOI: 10.1007/978-1-4471-2179-4_2,

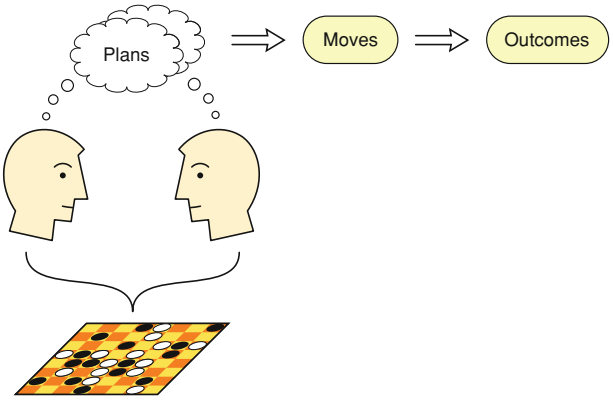

Fig. 2.1 Basic game model

We will follow this basic means-play-ends model at all levels of this study, from the specification of games to their measurement and ultimate creation.

2.1.1 Combinatorial Games

We focus on combinatorial games, which are:

- *Finite*: Produce well-defined outcomes.
- *Discrete*: Turn based.
- *Deterministic*: Chance plays no part.
- *Perfect information*: No hidden information.
- *Two-player*.

Such games may be called abstract games, board games, abstract board games, strategy games or simply abstracts by various players. However, these terms can have different implications for different players depending on their background, so the more precise term combinatorial game is preferred.

The two-player requirement is debatable as solitaire puzzles may validly constitute combinatorial games, in the sense that the puzzle solver competes against the null player and indirectly the designer who set the challenge. Multiplayer games with three or more players fall outside the scope of combinatorial play due to the social aspect of coalitions that may arise.

The term game shall henceforth refer to a two-player combinatorial game throughout this book. Such games are an ideal test bed for the experiments as they are typically deep but described by simple, well-defined rule sets.

Note that this book is not a work in combinatorial game theory (CGT), which is concerned with the analysis of games with a view to solving them or at least finding optimal strategies [7]. For the purposes of this study, the artificial player does not

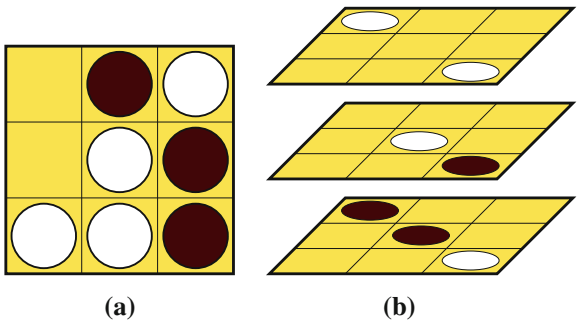

Fig. 2.2 Games of Tic Tac Toe and Tic Tac Toe (3D) won by White

need to challenge human experts and is of little interest except as a means for providing self-play simulations. While the AI must be of sufficient strength to provide meaningful playouts, we are concerned primarily with the quality of the game itself rather than the quality of the artificial player.

2.2 Game Elements

The following sections show how the rule sets of games can be broken down into their constituent elements and recombined to create new games. Creating new games is easy, but creating new high quality games is a much more difficult task.

2.2.1 Ludemes

Just as a meme is a unit of information that replicates from one person to another [19], a *ludeme* is a game meme or unit of game information. First coined by Borvo [11], this term describes a fundamental unit of play often equivalent to a rule; ludemes are the conceptual equivalent of a game's components—both material and non-material—and are notable for their ability to pass from one game or game class to another [42].

Ludemes may be single units of information, such as the following items that describe aspects of the game board shown in Fig. 2.2a:

```
(tiling square)
(size 3 3)
```

Conceptually related items may be encapsulated to form higher level compound ludemes as follows:

```
(board
  (tiling square)
  (size 3 3)

)
```

Collecting rules into such compound ludemes is a convenient way to describe games. For example, the essence of Tic Tac Toe may be succinctly described in the following expression (assuming a two-player combinatorial model):

```
(game Tic-Tac-Toe
    (board
       (tiling square)
       (size 3 3)
    )
    (win (in-a-row 3))
)
```

The concept of an entire game as a single item of information may seem odd but it is valid; there exist many examples of identical games being discovered, fully formed, at similar times. The most famous case is the independent discovery of Hex by mathematicians Piet Hein and John Nash in the 1940s [12]. A more recent example is Chameleon, discovered by New Zealand and USA designers within a week of each other in 2003. Such cases may be examples of "memetic convergence" in action towards optimal designs. Combinatorial games are typically described by simple, well-defined rules, making them especially amenable to such encapsulation.

2.2.2 Variants

Given a game in its ludemic form, it is a simple matter to manipulate its rules to create variants and new games. For Tic Tac Toe, such modifications might include the board size:

(size 2 2)

or the target line length:

(win (in-a-row 2))

However, a moment's reflection will reveal that each of these changes break the game, by making it unwinnable in the first case and trivially winnable in the second. Other manipulations might involve extending the board to three dimensions, as shown in Fig. 2.2b:

(size 3 3 3)

or inverting the end condition to give a misere version:

(lose (in-a-row 3))

These variants are both more interesting but still trivially solvable, and are more notable for their novelty value than any inherent value as games. There is much room for improvement in this branch of the *N*–in-a-row family.

2.2.3 Recombination Games

The difficulty of deriving an interesting game from Tic Tac Toe does not just stem from the fact that it is itself flawed (it is drawish if played correctly). There is the serious problem that rule sets for combinatorial games tend to be highly optimised and fragile; authors strive for the simplest rule sets that give the deepest playing experience, and the slightest change to a rule set will generally break the game. As with most creative tasks, it is easy to generate artificial content but much more difficult to generate artificial content of human expert quality.

It is unlikely that simple manipulations of an optimised rule set will produce an even better game in isolation, as the designer would usually have tested such obvious variants and discarded them as inferior. A more promising approach is to recombine the game's rules with rules from other games and look for the emergence [27] of interesting, new rule combinations not previously considered.

The rule sets of good games represent local maxima in the game design landscape, and any small changes to those rules will only go downhill in most cases. True innovation will occur when large changes move the search to another part of the design landscape where iterative improvement can climb a different local maxima, hopefully one that has not been explored before.

The idea that there pre-exist a multitude of games in the form of optimal rule combinations waiting to be discovered resonates strongly with the Platonist view of mathematics [28]. The question then becomes how to search this potentially huge design space effectively, and what fitness measure to use to guide the search. This task is an exercise in combinatorial creativity, and it is fortuitous that combinatorial games are not only combinatorial in play, but also combinatorial in design.

2.2.4 Game Distance

It can be useful to measure the distance of a newly devised rule set from known games to determine whether it constitutes a:

- duplicate,
- variant, or
- completely new game.

The distinction between a variant and a new game is subtle, but may be achieved by representing both games as rule trees and performing standard tree comparison to find the weighted difference between them. Differences between rules would be weighted more heavily, while differences between their attributes weighted more lightly, in inverse proportion to their depth (higher level rules generally have wider applicability and are therefore generally more important). If the total difference between the two rule sets exceeds a certain threshold value then the two games are considered to be distinct.

For example, the game on the right below, Tic Tac Toe (4 × 4), would be considered a variant of the game on the left, as the only difference is the board size attribute 4 × 4 as opposed to 3 × 3:

```
(game Tic-Tac-Toe
   (board
      (tiling square)
      (size 3 3 )
   )
   (win (in-a-row 3))
)
```

```
(game Tic-Tac-Toe-4×4
   (board
      (tiling square)
      (size 4 4)
   )
   (win (in-a-row 3))
)
```

However, the game on the right below, Group 4 would almost certainly be considered a new game in its own right. Not only has the entire (in-a-row 3) clause been replaced by (group 4), giving the game a different goal, but it has been mapped from a 3 × 3 square grid to a hexagonal grid with three cells per side:

```
(game Tic-Tac-Toe
   (board
      (tiling square)
      (size 3 3)
   )
   (win (in-a-row 3)
)
```

```
(game Group-4
   (board
      (tiling hex)
      (size 3)
   )
   (win (group 4)
)
```

Game distance becomes important when it comes to gauging the novelty of a new rule set [47].

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