

Growth and control of cancer as a metaphor of Go gaming

Matías Alvarado¹ and Carlos Villareal²

1. Departamento de Computación, CINVESTAV, 2. Instituto de Física, UNAM

Dynamic of control of territory in the game of Go, by black stones that play first, it could correspond to a metaphor of the born, growth and metastasis of cancer. And the game of white stones, that play the second turn, would correspond to the therapy of bounding and inhibition of cancer expansion. Each tactic of Go can be lightened into the cancer dynamic, and by this correspondence efforts in the mathematical modeling and algorithmic simulation in computer Go can benefit the efforts to successfully deal with the tumor dynamic of cancer.

I. The game of Go

Mathematical modeling and algorithmic setting of Go game is a meaningful problem in the state of the art of sciences. The complex interaction among elementary black and white stones over a squared board in Go gaming, looks-like similar to the modeling of complex interaction from simple elements in major nature [1, 2] and social phenomena [3, 4]. Formal analysis of Go game is core in advances in computer science likewise the analysis of Chess was during the 20th century [1]. Recent categorical triumph from AlphaGo over Lee Sedol, number 2 world Go player, is a meaningful triumph of Go game computational intelligence [6]. Moreover, this year AlphaGp won 60 online matches to top human Go players, <http://senseis.xmp.net/?AlphaGo>. A Go gaming state or Go state is a board configuration given by the combination of black/white/empty board positions, that is, the black/white/liberty Go gaming positions. An excellent site with diverse and whole Go game information is <http://senseis.xmp.net/>.

The recognition and discrimination of meaningful perceptual stimuli presupposes the active formation of stable perceptual elements to be recognized and discriminated. First, consider the spontaneous grouping of stones of the same color which occurs during visualization of a GO board, see <http://senseis.xmp.net/?WhatIsGo#toc2>. The stones are organized into distinct groups, clusters, or armies even though they may be sparsely scattered about or somewhat intermingled. Grouping is usually the result of proximity of stones of the same color or the predominance of stones of one color in an area, but can be affected by other characteristics of the total board situation. The area subtended by the board is divided into black and white territories, each of which maintains its own integrity in the visual held. These segments are a measure of the territory which is controlled by either side, hence are an important factor in the assessment of a GO board. Another example is the formation of "spheres of influence" about a stone or group of stones. Influence is not an inherent property of stones, but appears to be induced in them by our processes of perception.

Go is a 2 players, zero-sum and complete information game, black versus white stones that official go ban board is a 19 x 19 grid [7]. Goal of successful beat is to get the most of the board territory. By turn, each player places one black/white stone on an empty board cross-point position. Black plays first and white receives a compensation *komi* by playing the second turn [8]. Same color stones joined in horizontal or vertical line form up one

indivisible compound stone, hence long single stones are struggling for achieving territory control. One stones liberty is any contiguous vacant board cross-point in the vertical or horizontal direction not diagonal. Once a stone is placed on board is captured by adversarial stones by reducing their liberties to zero and is the condition to be removed. Placement of stone that would result in direct capture is suicide that is not allowed. A stone is alive if cannot be captured and dead if cannot avoid be captured. The game ends when both players pass turn. The score is computed based on both board territory occupied and the number of adversarial simple stones captured. The winner has the largest territorial control and the largest number of captures, as the most usual criteria.

Go match triumph is got by means of highly complex strategies constructed since the tactics before described. An early invasion or reduction move should be completed through placement of ally stones so close to connect them in few tries; a usual reduction move is to avoid the area be fully occupied by adversary stones. Go strategies follow sequences of actions being deployed using the aforementioned tactics. Hardest task is to evaluate the control board area and the dominion status of a player at a given stage of the game, for humans or computer players. Fig. 1 shows the flow diagram for computer Go gaming, which disarming simplicity not avoids a complex combinatorial process to attain efficient strategies [9, 10].

Go tactics

- i. Invasion: stones allocation in an empty board neighborhood
- ii. Reduction: stones allocation near of adversarial invasion stones to diminish their influence.
- iii. Eye: board empty cross position adjacent to 4 same color stones.
- iv. Atari: one stone is in Atari if is rounded by adversarial stones and has one single liberty.
- v. Stair: set of stones in Atari.
- vi. Net: set of same color stones doing a relax barrier to adversarial stones.
- vii. Connection: two same color stones sharing one liberty do connect by a third same color stone.
- viii. Ko: equilibrium between adversarial groups of stones such that each can does an equal mutual capture.

II. Cancer:

In cancer beginning, spreading and control the next characteristics are present.

1. Cells excessively growth, random appearance, in its near neighborhood.
2. Cancer creates its own net of blood glasses, angiogenesis, for propagation.
3. Metastasis: cancer cells can spring in a far neighborhood to the site they first spring.
4. Immune system do react to cancer spreading by:
 - a. Local level
 - b. Metastasis.

Go tactis interpretation in terms of cáncer dynamics, both of growth and control.

- a. Invasión: las células enfermas aparecen en la vecindad del tejido.
- b. Reducción: las células del sistema inmune, o la terapia de radio- o quimioterapia tratan de desactivar o desaparecer a las células cancerosas actuando en su vecindad cercana.
- c. Ojo, escalera: una vecindad rodeada de células cancerosas.
- d. Red: vecindad rodeada, de manera relajada, por células cancerosas.
- e. Conexión: de grupos de células cancerosas.
- f. Atari: grupo de células cancerosas rodeadas de manera adyacente por células sanas.
- g. Ko: equilibrio de fuerzas en una región del tejido.

III. Ising model for Go and cancer

We use the Ising model [1] classical tool for modeling dynamic changes in complex interaction to fundament the algorithm to quantify the cooperation strength among allied stones or tension against the adversary stones struggling in a Go game beat. At some moments during a Go match, a phase-transition-like process corresponds to strong preeminence of blacks over white or conversely. The ever intricate Go interaction and the need to measure each gamer' strength at any beat step is the major challenge to deal with. Nuestro objetivo es desarrollo de algoritmos para simular el juego de Go como la dinámica de dispersión y control del cáncer.

Asimismo, El modelo de Ising es relevante para el modelado de la evolución del cáncer [11], y la evolución de las células sanas a cancerígenas como un proceso de transición de fase [12].

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