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Performance Analysis of Tetris Game Variation Based On Shape and Time

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Abstract:*This Paper Is Based On A Variation Of Popular Puzzle Video Games 'Tetris'. This Variation Is A Win-Loss Strategical Game Where A Player Has To Score Points To Win. In This Paper, The Performance Of A Tetris Player Is Analyzed With Respect To Different Tetromino Shapes And Different Time-Dependent Scoring Functions. This Work, Also Adds Some Shapes Which Are Not Regular As The Original Arcade Version Of Tetris. To Understand The Performance Of A Player On Different Shapes And Time, Implementation Of This Work Is Simulated Numerous Times. This Paper ShowsThe Analyzed Result Of Simulated Games. The Findings Of This Paper Show That Performance Of A Player Depends On Holes Created By Shapes And Current Board State. Performance Is Not Enormously Depended On Time Is Also Shown In This Paper.*

Keywords –*Tetris, TetrominoShapes, Strategies, Games, Performance Analysis*

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I. INTRODUCTION

Tetris, A Popular Puzzle Video Game Was Introduced By A Russian, Alexey Pajitnov In 1985. Pajitnov Assisted By Dmitry Pavlovsky. At That Time Of Russia, Games Were Developed For Entertainment. In 2007, Tetris Declared As One Of The "Greatest Game Of All Time".

The Gameplay Of This Game Is Not Hard So People All Around The World Are Playing Tetris. Like Any Other Games, Tetris Games Have Also Some Rules. These Rules Vary From Variation To Variation Of Tetris. But Some Rules Are Remained Same For All Variations Like Completing A Row Will Give Points And Vanish That Row. This Paper Is Also Followed These Basic Rules. Also, This Variation In This Paper Adds Some Different Rules And Shapes Which Are Not Constructed With Four Squares To Compare The Performance.

This Paper Is A Modified Version Where This Tetris Is Not An Arcade Mode Puzzle Video Games. It Is Converted Into Win-Loss Strategical Games. In This Game, A Player Would Have To Score Equal Or More Points Than A Required Value Based On Time Given To A Player. Here This Paper Analyzed Winning And Losing Of Human Tetris Player On Different Shapes And Different Time Constraint.

The Complexity Of Tetris Is NP-Hard (NP-Hard Complexity Is Defined As A Problem Which Can't Be Solved By Non-Deterministic Turing Machine) [1]. For An Offline Version Of Tetris, It Can Be Shown That The Complexity Of Tetris Is NP-Complete [1]. This Paper Works On An Online Version Of Tetris. In An Online Version Of Tetris Player Does Not Know All The Tetromino (Tetris Games Shapes Are Known As Tetromino) Sequence In Advance. But In Offline Version Player Knows The Sequence In Advance. For Analyzing The Performance Of A Player This Game Is Run On Several Different Time Constraint With A Different Number Of Shapes. This Implementation Shows Only Current Tetromino. This Tetromino Is Randomly Generated So The Performance Of A Player Varies. For Same Time And The Same Number Of Shapes, The Same Player Can Win Or Lose For Different Events Of This Game. The Result Of The Game Is Not Fixed And Player Has To Play Optimally To Win A Particular Games Event. To Analyze Performance This Paper Uses Some Gameplay Strategies While Playing These Experimented Game Events.

II. THE THEORETICAL BACKGROUND

From The Very Beginning Of The Evolution Of Tetris, Many Research Paper Has Been Published In Different Journals. Many Researchers Have Given Their Important Theories And Proofs On Different Aspects Of This Game. The Original Version Of Tetris Is An Arcade Game In Which Player Can Play Indefinitely If Any Shape Does Not Touch The Top Of The Board. In 1992 A Research Paper Has Been Published, In Which

It Is Shown With A Mathematical Proof That There Is An End Of The Game With A Huge Number Of The Same Tetromino. This Paper Analyzes The Result With Only Z-Shape [2]. Then To Answer The Question Of That Paper In A Master's Thesis Which Shows How To Win A Tetris Game. In That Paper, Some Strategical Aspects Of Winning A Tetris Game Is Discussed. Later On, Many Other Papers Have Been Published Based On This Strategies. On Standard Game Board Size, An Analysis Is Done By Bertsekas And Tsitsiklis. They Discuss In Their Book [4] How To Use Of Policy Iteration Algorithms. A Bit More Precisely The Λ-Policy Iteration Algorithm. A Linear Programming Approach Is Proposed By Farias And Van Roy [5]. On Random Constraints Sampling And Reported Scores Of 4700 Lines On Average.

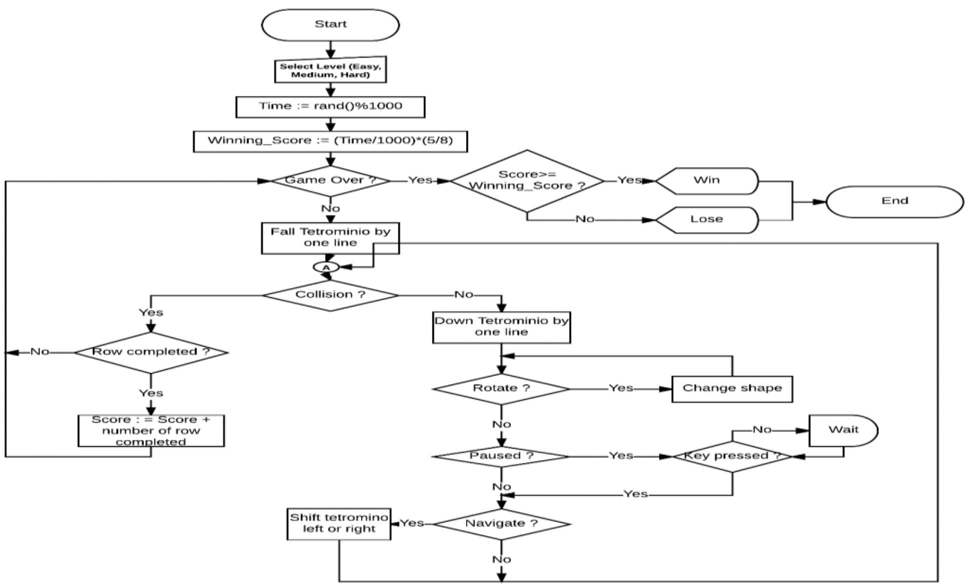
Now, This Era Is Running Into Evolutionary Computing. Now Evolutionary Computing Has Been Energetic To Search For An Optimally Weighted Combination Of Strategical Rules [6], [7]. This Two Papers Discussed The Different Rules And Heuristics To Develop A Better Gameplay. The Complexity Of Tetris Is NP-Hard But An Offline Version Of Tetris Is NP-Complete [1]. This Is Simplified By The Paper "Tetris Is Hard, Made Easy" [8]. Once A Piece Is Placed Down Player Will Not Be Able To Move Or Rotate The Piece Anymore. This Way Of Playing Tetris Was First Introduced By John Brzustowsky [3]. This Paper Follows This Rules. Now It Is A General Rule For Any Tetris Variation. After Placing A Tetromino It Is Not Possible To Change The Position Makes The More Complex And Interesting To Play.

For Machine Learning Purposes, Nowadays Tetris Is Used Widely. Many Theories Have Been Given For Machine Learning Purpose Of Tetris Games. To Design A Model For Machine Learning Genetic Programming Algorithm Is Used [10]. This Genetic Programming Algorithm Is First Introduced By Siegel And Chaffee [11]. To Design An Artificial Intelligence (AI) Tetris Player Amine Boumaza Defined A Very Good Scheme Of Designing A Tetris Player [11]. In A Bachelor Thesis By Max Bergmark Shows The Performance Improvement Using Breadth-First Search On Game Board [12]. Many Researchers Also Use Brain-Computer Interface For Tetris. Those Researchers Use Devices [13], [14], [15], [16].

III. PERFORMANCE ANALYSIS

To Analyze The Performance Of The Experiment, This Paper Follows An Algorithm To Design The Gameplay. This Algorithm's Flow-Chart Is Given In Fig-1.

Before Analyzing Overall Performance, First, Analyze Performance Based On Each Individual Shape. Some Shapes Or Tetrominoes Create Holes. The Shapes That Create Holes Increase The Difficulty Of The Game. This Paper Uses Some Shapes Which Are Created Holes To Show This Degradation Of Player's Performance. By Putting Shapes Optimally Will Reduce The Number Of Holes. This Optimal Option Is Not Fixed As Shapes Are Not Predefined. Many Strategies Can Be Taken To Minimize Holes. This Paper Uses Some Of This Strategies To Analyze Performance. For Experimental Purpose, This Paper Also Uses Some Shapes That Don't Create Holes Themselves But They Can Create Holes On Previously Settled Shapes. It Is Very Important To Reduce Holes For The Better Score.



Figuare.1: Flow Chart Of The Algorithm This Tetris Variation

As Tetromino Can Be Rotated, Rotation Of Tetromino Gives Better Advantage In Before Times. A Tetromino Can Be Rotated Only By A 90-Degree Angle. It Can Be Rotated In Four (4) Directions. Rotating

One Time Left Is Same As Three-Time Right Rotation. For Simplicity, This Paper Shows Only Left Rotation. It Can Be Also Shown For Right Rotation.

In This Paper, Many Shapes Are Used To Analyze The Performance. To Indicate A Specific Shape, This Paper Gives Names To Every Shape. Some Of The Names Of The Shapes Is Given By The Authors Of This Paper. These Shapes Are Not Common On Tetris, So They Have No Popular Name. Fracture Diagonal Shape Is Named As FD-Shape, T-Shape As It Looks Like T. Line-Shape Looks Like A Straight Line. Most Of The Shapes Are Named As They Look Like. Naming Is Not A Serious Concern In This Prospect. Shapes Are Represented In Fig-2:

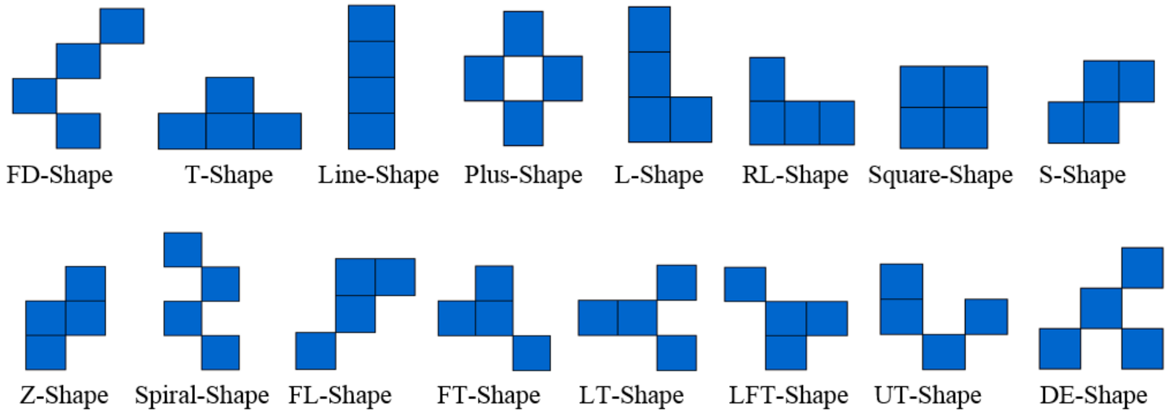


Figure.2: Shape Of Tetrominoes

Table 1: Holes Creation Table

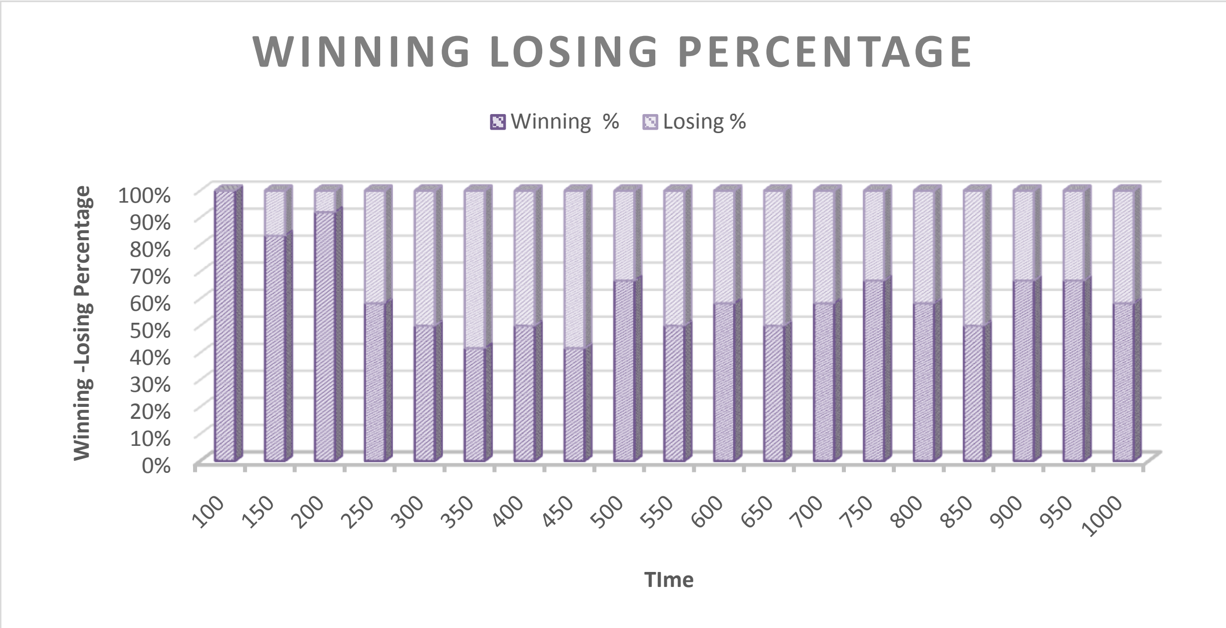
Shapes	Holes Creates			
	One Time Left Rotated	Two Time Left Rotated	Three Time Left Rotated	Four Time Left Rotated (Original Shape)
FD-Shape	4	4	4	5
T-Shape	1	2	1	0
Line-Shape	0	0	0	0
Plus-Shape	3	3	3	3
L-Shape	2	2	2	0
RL-Shape	2	2	0	0
Square-Shape	0	0	0	0
S-Shape	1	1	1	1
Z-Shape	1	1	1	1
Spiral-Shape	2	3	2	3
FL-Shape	3	0	0	3
FT-Shape	2	2	2	2
LT-Shape	1	2	4	3
LFT-Shape	3	3	2	2
UT-Shape	4	3	2	2
DE-Shape	1	3	2	2

From Table-1, It Is Shown That Each Tetromino Has Its' Own Complexity. Each Tetromino Does Not Create The Same Number Of Holes. In Table-1, Each Shape Is Considered As An Only Available Piece For A Single Game Board. In The Real-Time Application Of Tetris, There Are Many Shapes On A Single Game Board. So The Complexity Of Each Individual Shape Is A Minor Issue In Real Life. But This Complexity Defines The Overall Hardness Of The Game.

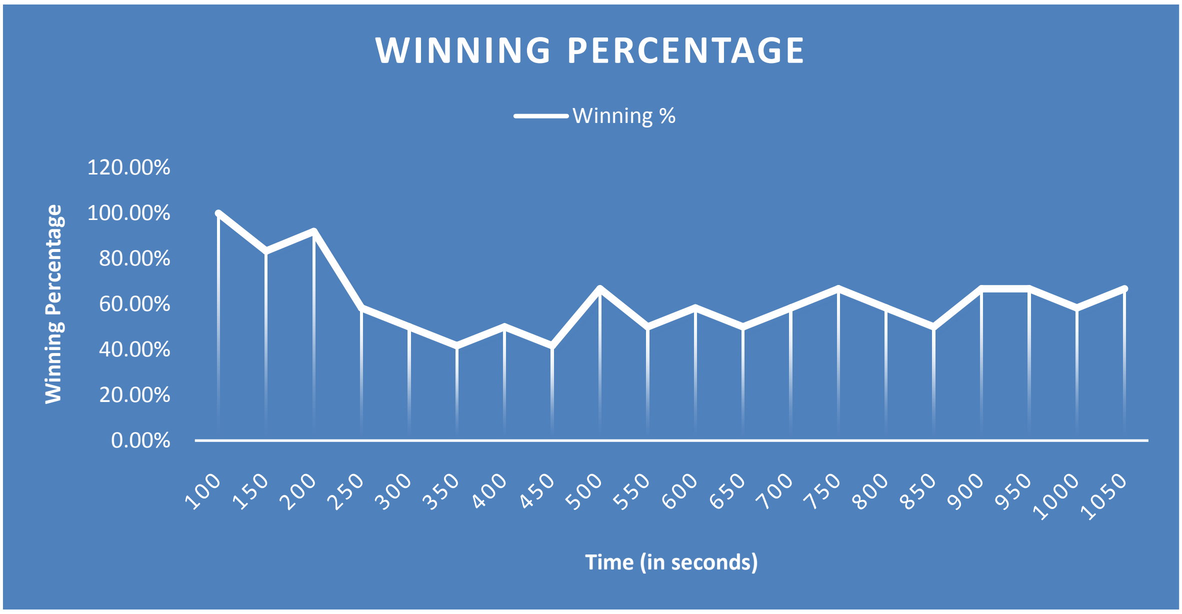
In Table-1, Shapes Which Are Not Connected Horizontally Or Vertically, Creates More Holes On An Individual Level. This Scarce Shapes Also Generate More Complexity For A Game. RD-Shape Creates Most Holes At Each Rotation. The Minimum Number Of Holes Is Created By RD-Shape And It Creates Four (4) Holes And The Maximum Number Of Holes Is Five (5). On Other Hands, Square-Shape Creates Least Holes On Each Rotation. Square- Shape Has Same Number Of Square Box In Each Direction. Rotation Of Square-Shape Does Not Create New Orientation Of Shapes. This Square-Shape Has No Complexity On Holes But It Can Create Holes On Board. As Tetris Game Board Is Not Plain Horizontally All Time, Square-Shape May Create Holes Also.

For A Game Which Is Not Deterministic (An Online Version Of Tetris), It Does Not Depend On Each Shape Complexity. For This Variation Of Tetris In This Paper, Time Is Considered As An Important Factor. Time Is Finite And Random. Player Or User Has To Score Equal Or Above Value To Win A Game. This Value

(Winning Score) Depends On Previously Fixed Random Time. To Analyze Performance, Time-Based Performance Is Analyzed In Fig.3.1 and Fig.3.2



Figuare.3.1: Winning – Losing Percentage (Bar Chart)



Figuare.3.2: Winning Percentage (Line Chart)

By Analyzing Fig.3.1 And Fig.3.2, It Is Seen That Winning And Losing Percentage Is Not Vastly Variant From One Time To Another. This Is A Huge Realization About This Version Of Tetris. It Can Be Also True For Any Time Depended On Scoring Function. This Paper Uses A Very Simple Function 'F(X)' To Define Winning Score.

F(X) = ((Defined Time % (mod) 1000) + 100) / 101

From Fig.3.1 And Fig.3.2, Winning Percentage Varying Between 41.47% To 66.67%. To Analyze This Percentage, Authors Of This Paper Played The Game Twelve (12) Times For Each Fixed Time. For Graphical Convenience, This Paper Shows Only Some Of These Values. Author Of This Paper Test The Game At 20 Sec Interval From 100 Sec To 1000 Sec And Analyzed The Result. These Values Give The Assumption That

Changing Time Does Not Make A Great Impact On Performance. Time Is Not A Major Issue As Tetrominoes Are Randomly Generated. It Is Proved That Offline Version Of Tetris Is Not As Much As Complex As An Online Version Of Tetris. If The Randomly Generated Shape Is Not Suitable For A Particular Game Board Current State Then This Shape Will Definitely Create Holes. Holes Are The Burden For Any Player In This Game. As Holes Are Created, Losing Option Is More Likely To Happen In Player's Fate. Winning A Game Sometimes Happens As The Miracle. This Is Not Happening All The Time, Sometimes Luck Favor's A Randomly Generated Shape Is The Shape Which Is Needed At That Particular Moment. This Types Of Incident Are Not Uncommon In Tetris.

IV. EXPERIMENTAL RESULT

In This Experiment On Tetris Game, It Is Found That Winning And Losing InThis Version Of Tetris Is Not Depended On Time. It Mostly Depends On Complexity Or Holes Created By Shapes. The More Holes Created By Shapes, The More The Probability Of Losing A Game. It Is Always A Better Option To Rotate A Particular Shape To Fit It With Previously Created Holes Or To Minimize Holes Creation For Current Shape. Holes Created By A Shape Not Only Depend On The Shape Itself But Also It Depends On The Current State Of The Game Board. If There Is A Change In The Game Board, The Same Shape At The Same Time May Or May Not Create A Hazard For The Player.

From Shapes In Fig.1 And Table.1 Can Be Easily Shown That The More Diagonal The Square Box The More Hole It Creates. Shape Only On Horizontal Or Vertical Axis Creates Fewer Holes Than Diagonal Ones.

The Complexity Of This Game Is Same As The Online Version Of Tetris. Its' Complexity Is NP-Hard. NP-Hard Problems Are Those Which Can't Be Solved By Deterministic Turing Machine Or Complexity Of Such Problems Which Can't Be Shown In The Polynomial Equation. Some Research On Tetris Also Shows Tetris Can Be Solved Using Dynamic Programming [1]. In Dynamic Programming, Tetris Game Is Very Hard To Solve As It Checks All States Of The Game Board. It Is Not Convenient For Real-Life Purposes As It Is Time-Consuming. Human Is Thinking More Optimally Than Machines. The Machine Thinks All Possible Solution To A Problem, But Human Tries To Choose An Easy Solution Of A Problem And Only Thinks Some Of The Possibilities.

From Fig.3.1 and Fig.3.2 This Paper Shows The Impact Of Time On Tetris Game To Win Or Lose. By Analyzing The Fig.3.1 and Fig.3.2It Is Seen That Time Is Not A Huge Impact On Winning Or Losing A Game. But By Changing Time Function 'F(X)' Percentage Of Winning A Game Can Be Changed. But The Ratio Of Winning And Losing For Different Time Will Remain Close To Other Time Functions. This Cause Gives The Assumption That Time Is Not A Major Factor For This Version Of Tetris.

V. CONCLUSION

In Short, The Performance Of A Tetris Player Mostly Depends On Current Board State And Falling Down Tetromino. Time Is Not A Major Concern For Winning A Game. Sometimes Time Makes An Impact If Current Board State Gives Opportunity. By Giving Demerit Points To Holes, Players Can Be Alerted To Choose A Nearly Perfect Shape Placement. This Research Can Be Extended By Analyzing The Machine's Performance. This Paper Has Some Limitation Like It Only ConsidersTwo Dimensional Shapes. Nowadays Tetris Is A Popular Game For Machine Learning Purposes. One Of The Findings Of This Paper Is This Win-Lose Strategical Tetris Games Complexity Is Not Differ From Original Tetris Games. In Near Future, Works Of This Paper May Be Extended For Machine's Performance And Three Dimensional Shapes. Limitations Of This Paper Will Also Be Tried To Resolve In Future.

REFERENCES

[1] E. Demaine, S. Hohenberger, D. Liben-Nowell, Tetris Is Hard, Even To Approximate, In: Proceedings Of The Ninth AnnualInternational Conference On Computing And Combinatorics (COCOON'03), 2003, 351–363.
[2] H. Burgiel, How To Lose At Tetris, Mathematical Gazette, 81:194–200, 1997.
[3] J. Brzustowski, Can You Win At Tetris?, Masters' Thesis, University Of British Columbia ,1992.
[4] D.P. Bertsekas And J. Tsitsiklis, Neuro-Dynamic Programming, (Athena Scientific, 1996).
[5] V. Farias And B. Van Roy. Probabilistic And Randomized Methods For Design Under Uncertainty, Chapter Tetris: A Study Of Randomized Constraint Sampling, Springer-Verlag, 2006
[6] N. B¨Ohm, G. K´Okai, S. Mandl, An Evolutionary Approach To Tetris, Proceedings Of The Sixth Metaheuristics International Conference (MIC 2005), Vienna, Austria, 2005, 1–6.
[7] D. Carr, Adapting Reinforcement Learning To Tetris, Bsc (Honours') Thesis, Rhodes University, 2005.
[8] Ron Breukelaar, Hendrik Jan Hoogeboom,And Walter A. Kosters,. Tetris Is Hard, Made Easy, Technical Report 2003-9, Leiden Institute Of Advanced Computer Science, Universiteit Leiden, 2003.
[9] John R. Koza, Genetic Programming: On The Programming Of Computers By Means Of Naturalselection, MIT Press, Cambridge, MA, USA, 1992.

[10] E. V. Siegel And A. D. Chaffee, Genetically Optimizing The Speed Of Programs Evolved To Play Tetris. In P. J. Angeline And K. E. Kinnear, Jr., Editors, Advances In Genetic Programming 2, 279–298.MIT Press, Cambridge, 1996.

[11] Amine Boumaza, How To Design Good Tetris Players, HAL, 2013

[12] Max Bergmark, Tetris: A Heuristic Study, Bachelor's Thesis At CSC, KTH, 2015

[13] Luo, A., Sullivan, T.J., A User-Friendly SSVEP-Based Brain–Computer Interface Using Atime-Domain Classifier, J. Neural Eng. 7, 2010

[14] Yasui, Y., A Brainwave Signal Measurement And Data Processing Technique For Daily Lifeapplications. J. Physiol. Anthropol. 28(3), Pp. 145–150 (2009)

[15] Rebolledo-Mendez, G., Dunwell, I., Martínez-Mirón, E.A., Vargas-Cerdán, M.D., De Freitas, S., Liarokapis, F., García-Gaona, A.R. Assessing Neurosky's Usability To Detect Attention Levels In An Assessment Exercise, Jacko, J.A. (Ed.) HCI International 2009, Part I.LNCS, Vol. 5610, 149–158. Springer, Heidelberg, 2009

[16] Crowley, K., Sliney, A., Pitt, I., Murphy, D., Evaluating A Brain-Computer Interface Tocategorize Human Emotional Response, 10th IEEE International Conference On Advanced Learning Technologies, 276–278 ,2010

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