# Extreme Intelligent in Critical Time using Dash Predator Swarm Optimization Algorithm together with High Speed Wireless by Realtime Processing

Khammapun Khantanapoka
Department of Computer Science
Faculty of Science Chandrakasem Rajabhat University Bangkok, Thailand,
doramon86@hotmail.com

*Abstract*—This research propose a new procedure for the path planning of ambulance, fire engine and police car which focus to critical time. These vehicles want traverse rapidly on the road while jam the traffic such as situation in burn of the building. It want arrive of ambulance, fire engine and policeman at the same time. It is badly situation and cause to increase jams the traffic. This paper proposes new method use search for optimum path planning in the critical time. It is important to safe life and asset of victim. [1] We propose Parallel of Mapping Analysis which use search for really distance in the real-world. [2] We propose Depth Direction A*(DDA*) which is appropriate with real-time. It take time less than A* and guarantee expand child node less than A*. [3] We propose speed detection algorithm of CCTV which install at cross of the road. We use CCTV search for rate of jam the traffic. [4] We proposes Client Itinerary Sampling Analysis Model which is tool for traffic management in the urban area.[5] We propose Predator Swarm Optimization Algorithm (P2SOA). It help determines choose optimal path rapidly and high complete rate. It generate several chromosome and rapidly more than other generation of GA. It determine base on condition optimum which is several factor in jam the traffic.[6]We propose technical in high speed wireless for transfer information from ad hoc to server. It will return the best route. [7] We propose Dash Predator Swarm Optimization Algorithm. It use create short-way by estimate obstacles which can destructible. We use improve mapping base on dijkstra algorithm. We compare three methods. First, we test DDA* algorithm together with parallel map. Second. We test Predator Swarm Optimization Algorithm (P2SOA). Finally, DDA* together with Genetic Algorithm. From the experiment, P2SOA takes time at least and return pathway which jam the traffic at least. Result of the experiment, this system take pathway best quickly than other algorithm 65.32-72.50 percentage.

***Keywords-Path Planning; Critical Time;Intelligent***

## I. INTRODUCTION

The path planning of ambulance, fire engine is related between times and seriously life. Future road traffic patterns can be modeled if there is knowledge of a planned instance of the non-road event (Normal traffic which can be scheduled in advance. concert, exhibition, sport event) or operation planned by traffic operator (transport of abnormal loads or road maintenance). Such information can be published for example via Scheduled Road Works [6] protocol describing time slot and possible range of influence. Another approach involves gathering information of expected attendance to a non-road event and its time frame. This way the gradient of traffic flow can be estimated and embedded in the city map. On the other hand, emergencies situation such as fire, flood, collapse building, earthquake, riot. This scenario has not information for solve the problem in advance. It must use data in real-time to solve immediate problems.

## II. LITERATURE REVIEW AND RELATED WORK

From GPS technology emerged it was possible to track the position of emergency vehicles more accurately and indicate the arrival of an emergency vehicle at an intersection much earlier [8] This approach adopted by Kim and Kwon used Dijkstra's algorithm for static path planning for the emergency vehicle and dynamically pre-empts the traffic lights as the vehicle travels along its route [9].

## III. ALGORITHM EXPERIMENT AND RESULT

This research proposes three methods as follows:

### *A. Parallel of mapping Analysis*

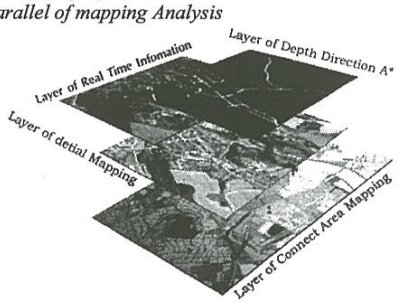


Fig. 1 Show operation of Parallel Mapping Analysis

Due to physical geography of world is sphere. It refers position on surface of the world with coordinate of latitude and longitude. We apply to GPS hardware. We cannot search

for path finding on plane of Grid Map and Octile in Manhattan type. Because, surface of the world is curvature. The path planning of A* in digital game cannot use reference really position on world. But it accepted rapidly and found target certainly. While Genetic Algorithm take time very much base on sampling operation, fitness function and search for optimum value depend to each condition. But it can use search for path finding on mapping of real world. We propose method solve a problem in contract defect with Parallel of Mapping Analysis method; we separate mapping to three layer. Top layer, we use for calculate path finding with DDA* on Manhattan type which rapidly but cannot refer really coordinate on surface of the real world. Middle layer, we use for update weight value of jam the traffic level to cost in DDA* which appear on the top layer. It will change each period time by display six colors represent level of traffic flow. We use information from CCTV. Below layer, we use for calculate path finding by reference from really coordinate of latitude and longitude. We use DDA* search for pathway rapidly and adding weight for choose optimal road which jam the traffic at least, finally, we traverse with really coordinate. Emergency vehicles is difficult avoid traverse in jam the traffic such as police car, ambulance and fire engine.

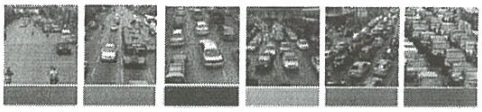

Fig. 2 level of jam the traffic represent with six colors.

The ground layer storage connection area, place is not a road, the narrow road which is traversable capability if change the type of car, obstacles which can be destroyed, forest that are not roads. It used to analyze the most serious emergency situations such as transport for very important personal (VIP). We called layer of connect area mapping.

*B. Depth Direction A* (DDA*)*

This research proposes Depth Direction A* or DDA*. The DDA* algorithm composes of two elements. A* algorithm works like brain to search for pathway between begin position to destination position and Depth Direction like eyes to plan an ad-hoc problem. First step, we define the start position and the destination position. Second step, it generates a straight line and calculates a slope value. It checks the state of octiles and adjust the proper procedure according to a particular situation. When current node has not adjoin-side to the hard obstacle.

$$m_{layer}=(y1-y2)/(x1-x2) \quad (1)$$

where *m* as slope of the straight line and when has one side of least adjoin hard obstacle adaptive to f(x)=g(x)+h(x). It use heuristic function in A* algorithm by h=Abs((x1-x2)+(y1-y2)) When g(x) as the actual shortest path distance from begin node to current node, h(x) as the estimated (or "heuristic") distance from current node to destination node, *f(x)* as sum total of *g(x)* and *h(x)*.

Fig. 3 Show DDA* that Yellow block is clue of expend child nodes. The center is A* classic

*C. Client Itinerary Sampling Analysis Model*

This paper propose model for sent signal refer optimal pathway analysis in critical time. We use Wi-Fi signal distribute to mobile which install in the police car, ambulance and fire engine at the same time after retrieve optimal pathway.

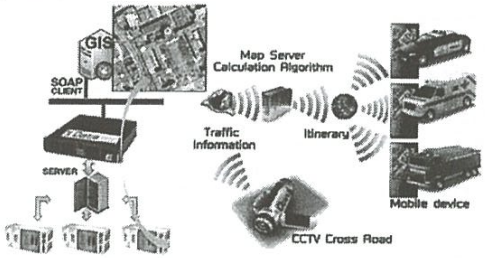


Fig. 4 Show Client Itinerary Sampling Analysis Model

We are tracking the ambulance's position gives possibility to suggest the best route from Emergency Management Centre's perspective. The server connected to traffic information provider which can do the repeat jam calculations and reports about current position. Directions optimal sent to a Navigation Device for assist each driver. We use System integration of Data Porter OPC client with OPC2SOAP extension in GIS application.

*D. Dash Predator Swarm Optimization ($DP^2SO$)*

We design and develop Predator Swarm Optimization Algorithm base on genetic algorithm for analysis search for optimal path base on several condition of animal which is predator. It consider from direction of each victim which is in front side. The victim tries avoiding congested pathway which cause to slowly movement. It catch slowly victim and follow excellent victim. It adjusts oneself to small size and extreme speedily.

***Seven Operation of Gene in Dash Predator Swarm Optimization.***

*1) Simple Cross* – Simple cross is a simple one point crossover between two of arrays of angles representing each path. *2) Subtree Cross* – Subtree cross is also a one point crossover. A node is chosen in each binary tree and the nodes as well as their children are swapped between the two trees. Another variant of this operator swaps the two subtrees in the same location in both trees. This crossover is

better than the simple cross. Each subtree, not consecutive values in the array holding the tree, represents a segment of the path. Using the subtree cross with the same cross site in both trees is equivalent to exchanging a portion of the two paths. *3)*Random Mutation -This mutation randomly selects one node in the binary tree and replaces its value with a random angle.*4) Small Mutation*-This mutation randomly selects one node and perturbs the angle contained. This operator is performed more and morefrequently as the number of generations increase and serves to fine tune an otherwise good path. *5) Flip Mutation* –This mutation randomly selects one node and makes a convex segment of the path concave or vice versa. This mutation can be used to target path segments that intersect with obstacles and perturb them into free space. *6) Proportionate Selection* – This operator propagates paths from one generation to the next giving each path a number of copies proportionate to its fitness compared to other paths and *7) Tournament Selection* – This operator propagates paths from one generation to the next by selecting the best path of from a number of randomly paths.

*D. Fitness Function of Predator Swarm Optimization*

A good path, first and foremost, must avoid collisions with obstacles. Then, when considering two paths the better one is defined as the path where less distance traversed on route to the goal. Keeping these two rules in mind, a suitable fitness function can be expressed as eq.2

$$f(p)=a_1\times\delta(p)+a_2\sum_{o_i\notin O} C(p,o_i,\Delta) \quad (2)$$

The first term is simply a scaled version of the length of the entire path. In two dimensions, this can be calculated by summing the Euclidean norms of all the path segments comprising a path as shown in eq.5

$$\delta(p)=\sum_{p\notin P}\sqrt{(\Delta y)^2+(\Delta x)^2} \quad (3)$$

The second term of (4) is a penalty function to assess against paths intersecting obstacles. It is computed by counting the number of collisions between the path and all obstacles, in the emergency's vehicle checked at some resolution, $\Delta$, along the path. By experimentation it was found that a ratio, $a_2/a_1$ of about 10 was best with $\Delta=0.1$. This fitness can easily be extended to penalize paths for traversing certain terrain or modified to push paths away from obstacles to maximize clearance. As mentioned previously, a genetic algorithm method can easily change the search criteria without modifying the entire planning algorithm. We determine base on fitness function in evolution of GA.

First step is generating chromosome process. We generate vector of probability value (p) which initial of each position as 0.5. We use simulation gene inside chromosome with vector pattern of probability. It is cause of use memory less than genetic algorithm which can generate to circuit of hardware.

Second step is selecting chromosome. It is selecting chromosome of parents (father and mother generation) for generate chromosome in next generation base on principle of selection and delete.

Third step is defining parameter of P2SOA

Fourth step is simulating chromosome. The chromosome will copy oneself to two chromosomes. A chromosome will controlled for non-mutation or mutate at least. It called leading. A chromosome mutate free from original chromosome. We call lagging. With this method effect to quickly search for optimum answer.

Fifth step is mutation in local search process. It is genetic variation effect to particularities of chromosome improved. We define mutate rate is stable and happen before the crossover process.

Sixth step is crossover in local search process. It is alternate gene by crossover for leading. It returns several chromosomes and cover every answer. While crossover for lagging which inherit hereditary characteristic from parent generation. The child chromosome has amount of chromosome more than double of parent. We must control number of chromosome which expands bit rapidly. We select child chromosome only high suitability for replace parent chromosome for next generation until altogether every chromosome.

Seventh step is compressed and compact chromosome and decompress. It help decrease rate of send data for calculation and increase speed in processing. We compress whole chromosome before consider in optimal of fitness function. It helps decrease size of data in temporary storage which has effect to decrease time in send data system than cGA. We use compress data with repeat data detection inside a part of chromosome. Example of compress chromosome, the pattern of repeat data composes three sections.

| | | | |
|---|---|---|---|
| Compressed data block 1 | Compressed data block 2 | … | Compressed data block n |

Fig. 5 show chromosome which compressed

| Length of repeating value | Repeat data count | Repeating value |
|---|---|---|

Fig. 6 Show Set of repeat data *n*

They use four bits for Length of repeating value and four bits for Repeat data count. Bit of Repeating value depends to length of repeat data. Example by 1000000 1000000 1000000 use twenty one bits which generate from 1000000 repeat three times. It uses storage only fifteen bits which is enough for accuracy and robust information.

| 0111 | 0011 | 1000000 |
|---|---|---|
| (a) | (b) | (c) |

Fig. 7 Show (a) Length of repeating value has7 bits, (b) Repeat data count data has 3 area, (c) Bit Repeating value is 1000000 by when decompress chromosome will return original data 1000000 1000000 1000000.

As shown in Fig.7 the compressed chromosome consists of compressed data blocks. Each block has 3 fields: length of repeating value, repeat count and repeating value. The chromosome needs to be decompressed before the fitness evaluation starts. The length of the decompressed

chromosome is varied. If the length of decompressed chromosome is longer than the size of the solution encoding, the excess string is discarded. If the length is less than the size of the solution encoding, the zero bits are added. The decompressed processing will decode one set of bit repeating value per times.

Example, chromosome 010000101000000110111100 which compose repeat data two sets (0100000101000 and 00110111100).

| | | | | | |
|---|---|---|---|---|---|
| (a) | 010000101000 | Repeat analysis to > | 0100 | 0010 | 1000 |
| (b) | 00110111100 | Repeat analysis to > | 0011 | 0111 | 100 |

Fig .8 Show two sets of repeat data (a) show frist set that bit repeating value is 1000, Length of repeating value has 4 bits or 01002 bits, Repeat data 2 times or 00102 times. (b) show second set that bit repeating value is 100, Length of repeating value has 3 bits or 00112 bits, Repeat data 7 times or 01112 times.

When dataset of (a) and (b) decompressed become to a original manuscript chromosome. Next step, we measure appropriate value of chromosome which decompressed. We check for each bit of chromosome by compare appropriate value and search for chromosome which has appropriate value more than on the other hand. We called chromosome of victor(winner). The chromosome which has appropriate value less than on the other hand, we called chromosome of loser.

If victor chromosome difference from loser chromosome then adjust probability value as follows;

Case One : if order bit i of victor is 1 use equation as

$$P[i]=p[i]+1/n$$

Case Two : if order bit i of victor is 1 use equation as

$$P[i]=p[i]-1/n$$

Where n is size of population

We will use compare fitness function for optimal answer.

Eighth step is calculation for fitness function. The properties of chromosome measured adapting to answer

Ninth step is comparison for fitness function in each round. We compare each fitness function in the same round. Next, we keep best chromosome which has distance between fitness function and answer at least in this round. It used compare with best chromosome in next round until found best parameter of answer.

Tenth step is turn back to third step until every parameter. Finally, we compare between best parameter of every parameter and choose best chromosome become to answer of problem. We will check status for found appropriate value of answer or not. Because, the condition in vector of probability will tendency 0.0 or 1.0 which can not guarantee found answer. Especially, In case of size of population n is a little value. It is effect to adjust a great number of values in each round rapidly. It is important consider effect to not found answer.

Case No ; the repeat operation in second step until found appropriate value of answer. Case Yes ; stop operation.

This model decides high accurately with local Search which improves from Particle Swarm Optimization(PSO). It is rapidly with several genes as double from gene object which Improved together with compress set of repeating genes which increase speed in calculation process. It is working high accurately while rapidly processes follow conceptual as Small –Rapidly – High accurately.

We use follow of principle of Miroslaw Jaskulowski, Shoaib Kamran and Olivier Haas. The rectangle can be small to cover just a point on the road. If the point is placed on the intersection, all paths leading to it are listed of bad times. This enables to exclude all road elements meeting certain criteria: obstruction such as an accident, road works or speed of traffic flow lower than predefined threshold such as concert, exhibition, sport event and rebel the state in some the area. Information must be planned in advance.

Supplied with special add-on, Personal Navigation Devices can receive Traffic Messaging Channel signals. They carry information in ALERT-C coding protocol of abnormal road conditions at particular points on the road. These points have unique id number and are stored in location tables together with relevant information, like their location. In the process of defining Traffic Messaging Channel location tables, highways and main transit paths are being prioritized due to limited number of locations, thus roads in metropolitan areas are barely covered. Traffic Messaging Channel signals messages reference particular place on the map and describe its condition – road works, accident, queues likely, length of the queue and many other. Itinerary calculation algorithms can automatically reroute basing on new path specification. And unlike in previous solutions the road parameters are not binary (clear / blocked) but in a way fuzzy, spreading path weight factors in range 0 – 1 for processing. What is more, the directions of traffic are distinguished. As an ambulance usually operates in certain area, the solution to deliver comprehensive traffic information lays in redefining the location tables by assigning all entries to the points in the area of service. Adding a Traffic Messaging Channel signals attribute to road element involves parsing GDF map file by a tailored application and further converting it to a format proprietary for each navigation software provider. On the server side, an application ascribes information from traffic management centre or predicted traffic pattern to the nearest point described in Traffic Messaging Channel signals location table and send an ALERT-C message in real-time. It needs to do so carefully, not to assign to a wrong traffic direction or wrong route. One of the methods bringing in-vehicle up-to-date maps is the use on-line communication methods mentioned above to send a map with current traffic conditions as road attributes (speed category). Using certain scheme, GDF can be converted to an exchange Meta Language format containing the same data but in different convention. An exchange mechanism comparing versions of data on the mobile device with the latest ones on the server side could push only these road parameters in region of interest which have been changed since the last update.

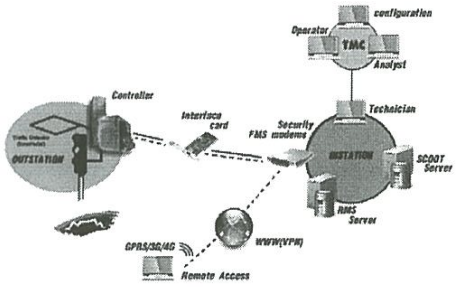


Fig. 8 Show Architecture of Traffic Messaging Channel

Furthermore a GDF converted to XML is over 10 times bigger in size so an update mechanism needs to warily filter transferred information as the connection's throughput in fast moving vehicle is limited.

One of the methods is tracking the ambulance's position gives possibility to suggest the best route from Emergency Management Centre's perspective.

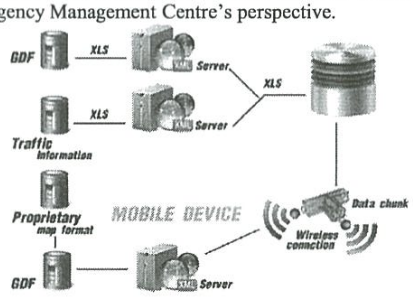


Fig. 9 Show Architecture behind incremental map updates

A server connected to traffic information provider can do the entire itinerary calculations basing on reports of current position. Directions are then sent to a Personal Navigation Device to assist the driver. In case of lack of connectivity, such solution is backed up by the algorithm of Navigation's Software but without current traffic information.

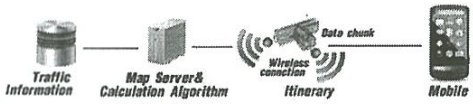


Fig. 10 Show thin client itinerary sampling

*E. Motion Detection with CCTV of Crossroad.*

We use information in this model for define parameter of ($P^2$SOA).First step, we separate static background with edge of movement object. We convert to gray color with equation We combine edge of movement object in frame $n$ and $n+1$.we analysis from Current Frame, Previous Frame and Background Frame.

$$\mathrm{Diff}_n = \partial(\mathrm{Frame}_n - \mathrm{Frame}_{n-1}) \quad (4)$$

We reduce noise with Gaussian convolution of canny edge detector. Next step, we can identify size and position of each car from CCTV with Square tracing method .It keep order of pixel position which is edge area. It calculates position of each car for center position of car, width and high of each car. Next, we separate each car to sub-image for compare similar of car in the next frame. We were tracking car search for speed and flow rate in cross road. We assure a car in difference frame with this equation.

$$\theta = \cos^{-1}\left(\frac{A.B}{\|A\|\|B\|}\right) \quad (5)$$

If vector A=B then $\theta = 0$ and degree of vector near 0 ;
It show very resemble of car. We use this method tracking car witch move in difference.

Third step, we calculate distance of car from position 1 to position 2 which is criterion of experiment. We apply trigonometric theory to speed detection as follows.

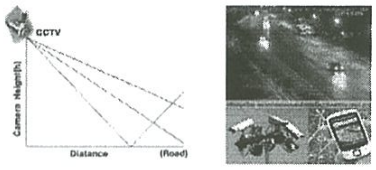


Fig. 11 Speed detection of CCTV in the cross road.

Fourth step, we calculate traffic flow rate of in several roads by CCTV in cross road is center analysis.

Finally step, we use $P^2$SOA search for optimal path with these parameter. *(1) Flow Rate* ($q_f$) *(2) Volume* ($q_c$) *(3) Time Headway* ($h_f$) *(4) Space Mean Speed* ($U_s$) *(5) Density of traffic*

It is similar flow of current or electric circuit. But the traffic flow system limit in term of three characteristic as follows; flow characteristic , speed of flow and density of vehicle. The relation of three elements applies to every situation on the road which replaces with $q=ku$. where $q$ is flow (amount of car per hour) by measure address a point on the road. $k$ is density (amount of car per kilometer) by measure address a short section on the road. $u$ is speed (kilometer per hour) by measure address a point or a section on the road. The three variables analyzed from traffic flow characteristic.

*G. Experiment our model.*

**First experimental:** 1) Parallel of mapping Analysis. 2) DDA* together with add weight to cost.

**Second experimental:** 1) Motion Detection with CCTV of Crossroad. 2) Factor of $DP^2$SOA which is generation of GA compare node and return optimal path.

| Factor | *Number of generation gene* (average) | | |
|---|---|---|---|
| | PSO | $P^2SOA$ | $DP^2SOA$ |
| **Flow Rate** | 1957 | 2138 | 2221 |
| **Time Headway** | 1886 | 2015 | 2069 |
| **Space Mean Speed** | 2103 | 2215 | 2282 |
| **Density of traffic** | 2124 | 2173 | 2312 |
| **The flexible level of jam the traffic** | 2311 | 2367 | 2434 |
| **Total of Take Time(second)** | 707 | 494 | 430 |
| **Accuracy of Optimal Pathway** | Worse | Fair | Best |

## IV. RESULT OF EXPERIMENT

We propose High Speed Wireless Model(HSWM) for communication between three vehicles for solves a problem together with $P^2SO$ and we called $DP^2SO$. In our experiment, we compare between two experiments. We use map from Google Earth 150 map by size 1024 to 728 pixels. We view image from CCTV image (traffy.nentec.or.th) addressed 35 crossroad in Bangkok city and London city. We test efficiency with two experiments. We test same area in three times which difference by jam the traffic. Result of the experiment as follow; ***First experimental;*** The table has compared the execution time in seconds. Table below Show Result of shortest part Algorithm. ***Second experiment;*** We test efficiency of Dash Predator Swarm Optimization Algorithm (DP2SOA) using compare with Particle swarm optimization algorithm (PSO). They work together with DDA* by Fitness function 143 Km.

*Remark* : It calculate as stable when traffic flow rate on statistic of period time. The accurate base on Dash Predator Swarm Optimization Algorithm ($DP^2SOA$) than sample equation as $v=ds/dt$ where $ds$ is movement of car by distance and $dt$ is movement of car by period time, By PSO mean Particle Swarm Optimization Algorithm.

## V. CONCLUSION

The operation of Depth Direction A*(DDA*) can working together with weight value inside middle layer of Parallel Mapping Analysis. It is able to search for optimal path in the time which jams the traffic. It takes time less than work together with Genetic Algorithm. However, the level of jam the traffic must define before really time from statistic information in the previous time. The optimal path depends on frequency of update and adjusts level of middle layer. The prominent point of DDA* together with weight value is rapidly in the analysis step. The efficiency of avoid jam the traffic less than Predator Swarm Optimization Algorithm ($DP^2SOA$) . It is working rapidly than A* together with Genetic Algorithm which happen in research of A. John Sanjeev Kumar and colleague (Intelligent Transport Route Planning Using Genetic Algorithms in Path Computation Algorithms)

Dash Predator Swarm Optimization Algorithm ($DP^2SOA$) can choose path which is efficiency of avoid jam the traffic more than DDA* algorithm. It can analysis in real time pattern and factor analysis better than first experiment. It covers factor of jam the traffic more than first experiment. It has high efficiency for avoid jam the traffic in the critical time which depend on efficiency of image processing. HSWM technique helps decision rapidly.

| Algorithm | Take time (average) | Accuracy % |
|---|---|---|
| A* & GA | 291 | Worse |
| DDA* & GA | 284 | Fair |
| DDA* & $P^2SOA$ | 198 | Fair |
| DDA* & $DP^2SOA$ | 156 | Best |

However, the feature of DDA* algorithm is decrease expand child nodes 22.12-70.67% in single layer and 50.12-58.67% in multi-layer depend on property of terrain when working alone. The DDA* together with information of pathway in database decrease expand child nodes 69.12-70.67% and increase speed to 36-46%. The DDA* increase speed and smooth of pathway and use pathway recorded in database up speed extremely. ***Depth Direction A* algorithm*** is very smooth pathway and expand nodes less than A* classic algorithm. It is planning avoid obstacle before process. It guarantee expend child nodes less than A* classic algorithm.

## REFERENCES


[1]Khammapun Khantanapoka,Krisana Chinnasarn"Pathfinding of 2D & 3D Game Real-time Strategy with Depth Direction A* algorithm for Muilt-Layer ". Bangkok, Thailand. Eight International Symposium on Processing pp.145-150, Sep 24-25, 2009 .

[2] Khammapun Khantanapoka, "Real-time Spider for Intelligent Traffic in Critical Time with Predator Swarm Optimization Algorithm", ACTIS20011 National conference on Applied Computer Technology and Information system, Bangkok, February 2011

[3] Khammapun Khantanapoka, "Dynamic Path Planning for Multi-Size Agent in Heterogeneous Environment with Intelligent Cyberspace" Experimental, 2nd International Conference on Knowledge and Smart Technology ,Burapha University Thailand. Chonbure, November 2010

[4] Khammapun Khantanapoka, "Path Planning of Very Important Personal Protection in Urban Location using Intelligence Evolution Algorithm" , 2010 International Conference on Electronics and Information Engineering Kyoto, Japan, August 1-3, 2010

[5]Khammapun Khantanapoka, Suwanna Rasmequan,"The pathway for agent and robot enemy in strategy game with high efficiency model. 5th IEEE International Conference on Intelligent Systems, IS 2010, University of Westminster, London,UK pp 462-467,7-9 July 2010,

[6]Daniel Harabor, Adi Botea."Hierachical Path Planning for Multi-Size Agents in Herterogeneous Environment". Perth, Australia. IEEE Symposium on Computational Intelligence and Games (CIG'08), pp.258-264, Dec 15-18, 2008

[7] T. C. H. John, E. C. Prakash, and N. S. Chaudhari, "Team AI: probabilistic pathfinding," in Proceedings of the International Conference on Game Research and Development, vol. 223 of ACM International Conference Proceeding, Perth, Australia, December 2006.