Review on Virtual Human's Affective Model and Related Applied Algorithm

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ABSTRACT: *The artificial intelligence simulation with virtual humans in virtual environment is considered as a research focus after movement simulation in field of artificial intelligence and simulation with virtual human include affective model and influence of affection to movement planning of virtual human. It's necessary to review on virtual human's affective model and related applied algorithm. A* algorithm is the main heuristic algorithm in artificial intelligence to search for the optimal solution of embodiment's path planning. In miscellaneous ergodic algorithms and heuristic search algorithms A* algorithm both has its own advantages. But facing more intricate virtual environment A* algorithm need to be improved by effective affective evaluation to get more flexible, comprehensive and humanized optimal path.*

Categories and Subject Descriptors:
I.2 [Artificial Intelligence]: Cognitive Simulation **I.2.8 [Problem Solving, Control Methods, and Search]**: Heuristic methods

General Terms: Artificial Intelligence Simulation, Applied Algorithms

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1. Introduction

Virtual human has become a hot topic in many scientific fields. In the field of computer science, the study of virtual human refers to the geometric characteristic and behavioural characteristic human showing in the virtual space, as well as the multi-function sensation and affective computing. The study of advanced intelligent behaviour mainly focuses on how to make intelligent virtual agent to be like a real human, including the simulation of human thinking, and even emotion [1] [2]. Researches put forward the idea that an intelligent virtual host should possess an advanced ability to show its psychological and affective state [3]. They are now focusing on the building of an affective model, which will help to promote the intercommunication between user and the virtual space. This study, though still in an early stage, is critical to this paper.

Affective computing can be divided into 9 parts according to the process: affective mechanism, affective communication acquisition, affective model identification, affection modelling and understanding, affection synthesis and express, affective computing application, affective computer interface, affection transference, and wearable computer [4]. It is an intersection of multi-disciplinary study involving sensor technology, computer science, cognition science, psychology, ethnology, physiology, philosophy and sociology [4]. It aims to endeavour the computer with human-like affective ability, and its key technology includes analysis of human physiology, psychology and behaviour, study of human affective signal acquisition sensor, computer modelling of human emotion and behaviour, identification technology of biometric characteristic, integration and inference system of information and knowledge, and effective way of showing emotional perception.

2. Review on Affective Model of Virtual Human

Hidden Markov Model, put forward by MIT media lab, is able to draw a corresponding emotion according to human affection probability, and obviously the probability of anger to rage is higher than to happiness. HMM [5], based on an affective model, applies the concept of affective office and sentiment office to constraint the initial value, so as to fit itself into different characteristics. Another model [6], regarding human affective process as a two-level random process, covers all human characteristics by adjusting the initial value, and predicts the result in probability.

An affective state space [7] is built, simulates the unrest degree of affective behaviour in a same dimension environmental state by applying affective coefficient. A series of nodes is built on the basis of OCC affective mode [8] to show the characteristics, which can be changed by moving or modifying the nodes. Markov chains is used to construct an affective probability space [9] to build a model simulating the emotion change, clarifies the relationship between affective intensity, affective energy and affective office, imitates the dynamic process of affective state, and provides a new vision to affective computing and affective automatic generation theory. Besides these, a structural model [10] is built for emotion robot based on Multi-Agent. It introduces a grey system based affective model and affective-related model, constructs a learning model for robot, and achieves the intercommunication of human and robot in both intelligence and emotion.

Scholars like S. Kshirsager [11] put forward a model used in the dialogue with virtual human mood, character, and emotion. He achieves the mapping from text entry to virtual human emotion and behaviour by quadruple type. H. Ushida [12] proposes an affective model based on rule mechanism. It is made up by responding system and planning system, the former produces an instinct response to stimulation, and the latter controls emotion and mood. The essence of this mood is the interaction between emotion and cognition in the thinking process. Kismet [13] studies a three-dimensional space affective state space made up by arousal, valence and stance. The whole space is divided into different districts centred by emotional-stated points, and each district stands for a specific emotion state.

D. Cadamero [14] constructs a system simulating physiological changes. This system is able to imitating the process from physiological feeling to emotion generation by simulating human physiological system. It provides a new way to explore the influence of physiology to psychology. Frijda [15] constructs another affection-focused model to meet artificial requirements. This model is based on affection adjustment of internal motivation to external needs. In the process of exploring and constructing affect-generate model, the exploration of CogAff-generate model, which is more suitable for computer simulation, has drawn attention from researchers. OCC model is the 1st CogAff-generate model. Together with Roseman Theory [16], OCC model provides a rule-based mechanism for CogAff generation.

However, affection does not simply follow theory deduction. It will be also influenced by non-cognitive factor as well. C. Lzard [17] shows the influence of non-cognitive factor to affection, and puts forward a “four-type affective generator” concept, namely central nerve affective generator, feeling affective generator, motivation affective generator and cognition affective generator. Velasquez, J.D. from MIT [18] [19] puts forward a complex affective generator model Cathexis on the basis of the four types. This system is made up by specific agent, each standing for a basic emotion state, and can have influence on output behaviour. But different form OCC model, Cathexis model only has one core rule, the emotion updating rule. The CogAff agent architecture put forward by Sloman [20] is another complex affective computing model. It shows the “self-monitoring” process in affective computing study and opens a new field in affective study. But it is less applicable compared with Cathexis model.

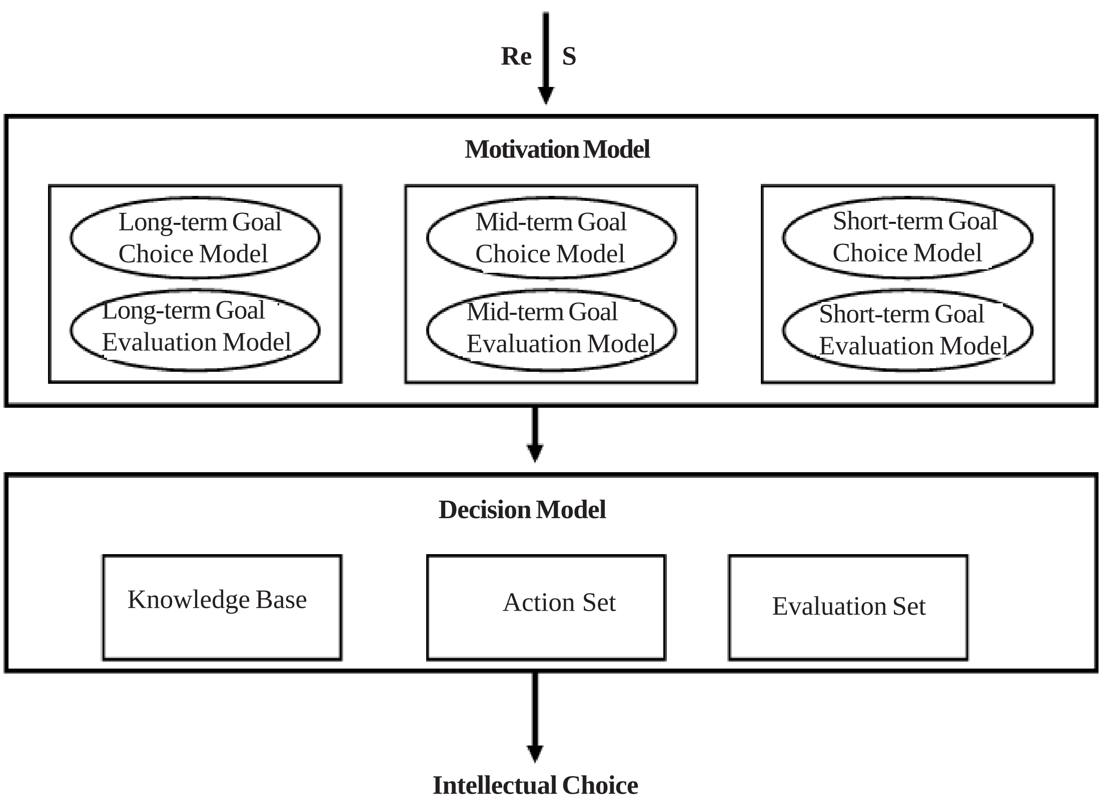

Figure 1. Process of Intellectual Decision

3. Analysis on Affective Model of Virtual Human

Nowadays, most intelligent system applies CASE sentence in information processing. For example, if there are X environmental state information, each may have Y states, then the possible quantity of composite state is X * Y; if there are M self state information, each may have N states, then the possible quantity of composite state is M * N. If consider environmental and self state information together, then the possible state space is X * Y * M * N. This space is obviously huge, therefore only typical and predictable state will be taken into account. Although being dynamic and unstable in actual use, CASE state is usually considered stable, and regarded as a subset of the entire state space by the intelligent systems. This phenomenon in turn leads to the system's incapability to cope with the dynamic environmental change.

In traditional AI system, the intellectual decision process regardless of affection interference can be shown as Figure 1.

Re stands for requirement, S stands for environmental state information, they go through the motivation model made up by long -term goal, mid-term goal and short term goal, as well as the decision model made up by knowledge base, action set and evaluation set, and finally come to the intellectual decision. Thus, with the change of environment, this system is able to make an intellectual decision suitable to the pre-build world mode according to the requirement. However, this process is only workable in a stable environment as a virtual environmental model is unable to cover all the changes. In order to promote the flexibility in an unstable environment, researchers build an affection model on the basis of intellectual decision. It is a system based on virtual human sensitivity model and emotion model. The intelligent system including an affection model is shown as Figure 2:

This system includes requirement model, impression model, emotion model, instinct model and intelligent mode. The former two models are very important, and will be introduced below:

(1) Requirement Model: the requirement of an intelligent system. It receives the environmental state information S, and is affected by both IM in impression model and output E in emotion model. This model will adjust the requirement according to the emotion feedback and impression feedback. Different from the traditional way, the new intelligent system, represented by Agent BID model, takes the mental model of Agent into consideration. However, the type of mental model that help to build the program is still unknown

(2) Impression Model: this model receives the output,

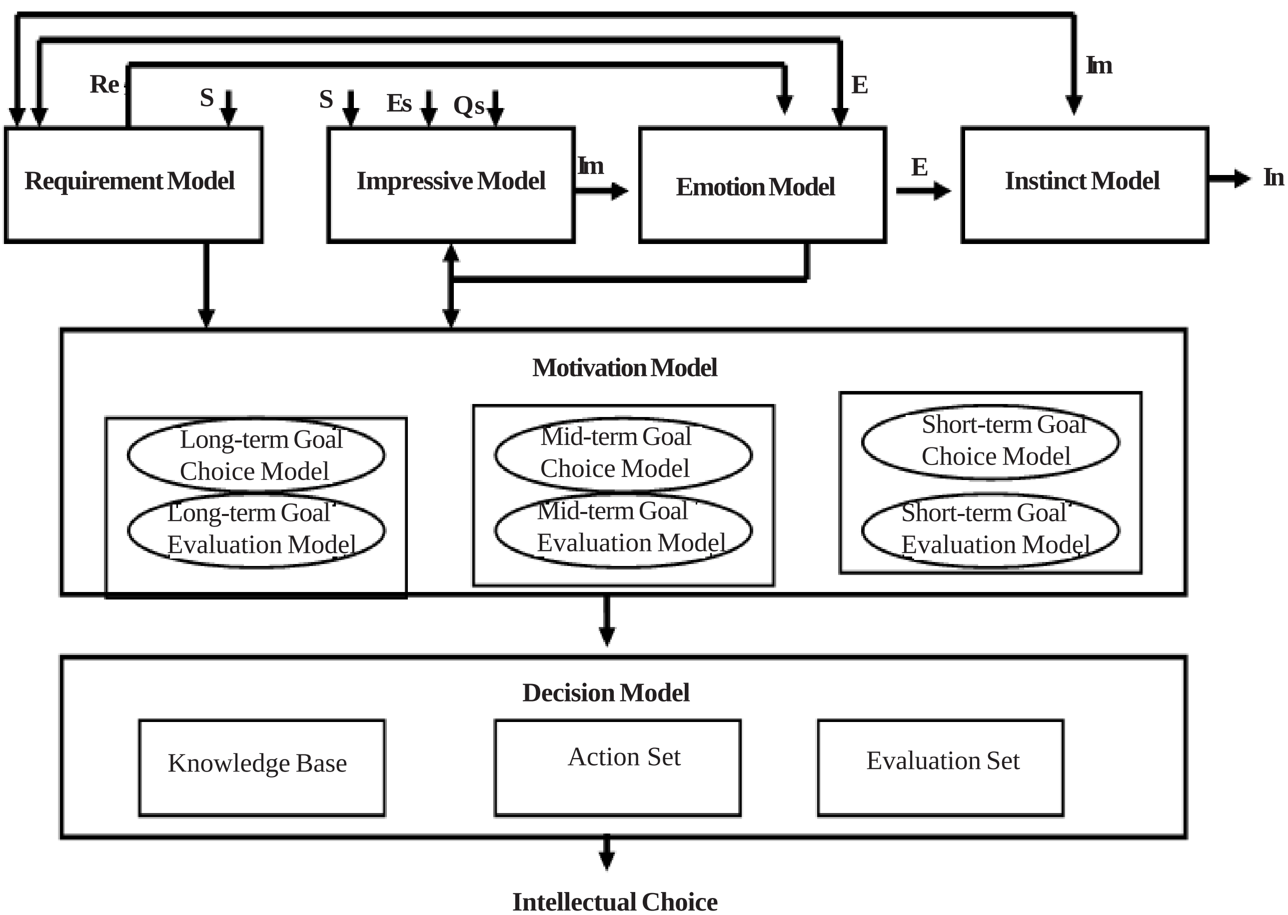

Figure 2. Intelligent System Including an Affection Model

information of vision model, including self state information environmental state and other intellectual state, interfered by feedback E of emotion model, and finally produces the feeling to the current state. It is the reflection of environmental change. While a virtual environment model can be built to cope with the certain change, it is unable to be built to an uncertain one.

Sensation usually refers to vision, auditory, olfactory, taste, skin, kinaesthesia and balance. This paper is based on the vision sensation. The essential question in cognition science is memory. Memory is a main topic in cognitive psychology; it is the calling procedure of experience and knowledge. While the study in cognitive psychology focuses on understanding memory, the study in computer science focuses on computer application. The procedure of cognition is known as transmission and processing of information in the brain basing on the memory. Memory is a gift from evolution, an important ability in the unpredictable environment, a key in optimizing behaviour choice and promoting human adaptability. Human and other intelligent creatures are able to keep in memory the scenes they perceive, and draw a decision environment by these scenes. The independent generation of character intention is usually influenced by decision environment and the role itself [21]. Modern cognitive psychology divides the basic memory model into three stages. As shown in Figure 3, memory can be classified into USTM, STM and LTM, each involving the stage of encoding, storing and distracting.

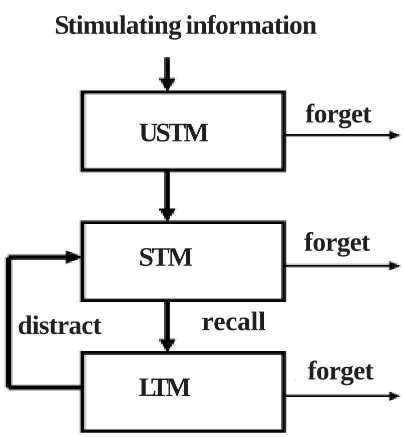

Figure 3. Three-stage Memory Model

USTM (Ultra Short-Term Memory), also known as sensory memory, is a filter in the cognitive process. It filtrate the assessed information and discards the useless one.

STM (Short-Term Memory), also known as working memory or direct memory, will make a short-term record on the sensed memories, and keep them available for reminiscence. It is a platform, distracting and processing necessary information from LTM base, and storing the accumulated information back. STM is a complex information processing system which plays an important part in decision-making.

LTM (Long-Term Memory) is a huge and complex date base, storing all the knowledge about the world. It can help human to recall events, recognize models, reason and solve all the problems.

The achievement in cognitive psychology about remembering, forgetting and recalling can be a reference in the study of virtual human cognition and memory. It helps to imitate the memory process of virtual human, and enhance its living ability in virtual environment.

The study of psychology and ideology shows that intention comes before behaviour, or as it usually puts, intention guides behaviour. By feeling the external environment and self state, emotion system generates the most pressing intention of virtual human, forms a motivation through motivation model, makes a behaviour planning, takes action, and influences both environment and self state. The virtual human vision system detects these changes, repeats this procedure, and forms a circulation feedback mechanism.

4. Movement Planning and Review on A* algorithm under affective perspective

The virtual human senor behaviour planning is based on the AI automatic planning theory. By going through the process of virtual human reasoning and decision-making, it selects a most suitable behaviour sequence for the realization of motivation and satisfaction of virtual human needs. A basic plan includes four parts: objective, premise, body system made of sequences and sub-objective, result. The process of a virtual human building a senior behaviour planning can be listed as follows:

(1) Objective: output of a motivation choice by motivation model.

(2) Premise: creation of virtual self state and environment state, and precondition acquired from knowledge base.

(3) Body system made of sequences and sub-objective: satisfaction of the constraint condition, coordination of the virtual behaviour, and finding of the best action plan.

(4)Result: achievement of the motivation.

For instance, virtual human needs to move its embodiment from point A to point B, and point A and point B may exist in the same virtual scene Z_0 or in different virtual scenes Z_0 and Z_1 respectively. Then virtual human needs to find a path from point A to point B straightly in Z_0 or through interface between Z_0 and Z_1. There may be some obstructions, some other embodiments or some other moving objects in the virtual scenes, and some of them may be with aggressive nature. Generally speaking virtual human is going to control the move of embodiment depending on visual sense, and problems following about the visual sense need to be solved:

(1) How to discriminate miscellaneous objects in current virtual scene.

(2) How to deal with miscellaneous abnormal conditions

in current virtual scene and appoint the optimal path from own affective choice.

Embodiment in a constructed virtual scene has some degree of path planning ability itself, so while controlling an embodiment human just need to indicate the position of object point B and send out order of carrying out the move. Then embodiment can plan out shortest path and keep away from obstacles by itself before arriving at point B, and wait for the next order from human after arriving at B. There is no noteworthy difference between virtual human and real human while controlling similar embodiment in virtual scene except that virtual human need to pay close attention to whether there is abnormal behavior in embodiment's moving, and while appearing abnormally virtual human need to make corresponding processing depending on it. Abnormal conditions include that embodiment sticks fast by some obstacles, embodiment doesn't select the optimal path, and so on.

Generally embodiment has path planning algorithm itself designed by virtual environment, but abnormal conditions may still exist. So virtual human is necessary to plan and interpose path of embodiment's moving from own more complex affective choice.

A* algorithm is the main heuristic algorithm in artificial intelligence to search for the optimal solution of path-navigation. Its basic principle is to assess possible next points of all routes to next state space point B with evaluation function in search process and then decide go on moving from which next point A1 to point B depending on the valuations in order to realize the optimal path search. Evaluation function can be described as:

$$F = G + H$$

F is evaluation function for estimating the movement cost from A to B. G is the movement cost to move from the initial starting point A to a given point following the path generated to get there. H is the estimated movement cost to move from that given point to the final destination point B. The optimal path is finally generated by repeatedly going through "open list" and choosing a series of points with series of the lowest F score.

A* algorithm, DFS algorithm and BFS algorithm are all ergodic algorithm of virtual state environment. A difference among them is that A* algorithm carries out selective traversal search by reasonable and effective evaluation function H that is also the core and value of A* algorithm.

A* algorithm, local search algorithm and best-first search algorithm are all heuristic search algorithm with heuristic function. But they are different in Strategy of selecting the best search node. Local search algorithm gives up the other brother nodes and father node after choosing the best search node in search process and has always to search down. As a result of giving up other nodes, the best search node is likely to be given up at the same time because it may not be the current best search node. Best-first search algorithm doesn't give up nodes except they are dead nodes and compare score of current node with score of previous node in each evaluation to get a better node, which is in order to avoid losing the best search node effectively.

A heuristic algorithm with strategy of $F = G + H$ need to possess following states if it belong to A* algorithm:

(1) There need to be the optimal path from A to B on search tree.

(2) Problem domain is limited.

(3) Search cost score of Child nodes of all nodes W > 0.

(4) Actual cost score H* > H.

A* algorithm can work out the optimal path about state space search problems in the shortest time. The closer gap between evaluated cost value and actual cost score is, the more effective appraisal function H is. A* algorithm is obviously better than Dij* algorithm because the latter searches around without directivity. Algorithm process of A* can be described as following:

```
function A* (A, B)                                   //start point, goal point
   closedset := empty set                             //closed list
   openset := set containing A                         //open list
   come_from := empty
   g_score [A] := 0                                  //G
   h_score [A] := heuristic_evaluate_of_distance (A, B)        //H
   f_score [A] := h_score[A]                           //F = G + H
   while openset is not empty
      X := node with the lowest f_score[ ] value in openset
      if X = B
         return reconstruct_path (come_from, B)
      remove X from openset
      add X to closedset
      each Y in neighbor_nodes (X)
         if Y in closedset
            continue
            tentative_g_score := g_score [X] + dist_between (X, Y)
         if Y not in openset
            add Y to openset
            tentative_better := true
         elseif tentative_g_score < g_score [Y]
            tentative_better := ture
         else
            tentative_better := false
         if tentative_better = ture
            come_from [Y] := X
            g_score [Y] := tentative_g_score
            h_score [Y] := heuristic_evaluate_distance (Y, B)
            f_score [Y] := g_score [Y] + h_score [Y]
   return failure

function reconstruct_path (come_from, current_node)
if come_from [current_node] is set
      T = reconstruct_path (come_from, come_from   [current_node])
      return (T + current_node)
else
return current_node
```

5. Introduction of a improved A* Algorithm for Virtual Human's Path Planning

There are three main steps to improve A* algorithm for virtual human's path planning [22]. First step is process of weighting. Usually estimator function h(n) refers to the Euclidean distance of two nodes, therefore it will be even shorter than the actual shortest distance. This function ensures feasibility but lowers searching efficiency, so it will be weighted by the following lemma here.

Every step before the end of A* algorithm has a node n*, the characteristic in OPEN list can show as follows:

1) Node n* is on a best path to destination node.

2) A* algorithm has found a best path to destination node.

3) f (n*) ≤ f(n0)

Then this is acceptable.

If further extended, if all functions lower than h is feasible, this weighting is feasibility. According to the lemma above, this paper uses a weighted estimator function as follow:

$$f_w(n) = (1-w)\, g(n) + w\, h(n)$$

if $w \in (0.5, 0.9)$ then the weighted function will have no interference on the feasibility of algorithm, and is able to find a solution. So this weighting method is not only feasible, but also can increase the search efficiency of algorithm.

The second step is introduction of artificial searching marker. The traditional A* algorithm may trapped by *"calculating"* or *"narrow"* barrier, and fall into Dead state. Therefore, a definition of *"incredible node"* is necessary in avoiding these traps. *"Incredible node"* here means: in a grid environment, the neighbouring group of structural point $A(x, y)$ is $P(A) = \{ (x, y) \mid x = A_x + i, y = A_y + j$, and $(x, y) \neq A, i, j \in \{-1,0,1\}\}$, when $i, j \in \{0,1\}$, the points $B(x, y)$ meets $h(B) < h(A)$, and $B(x, y)$ in the group of barrier, then $A(x, y)$ is the *"incredible node"*.

To avoid the virtual human trapped in the "calculating" or "narrow" barrier, we should allowed virtual human walking in the narrow path. When virtual human meets an "incredible node", he will consider this as a potential barrier, and add it into the group of "artificial searching marker". On the backtracking, virtual human will do a reversal search on the marked father node, mark all other nodes he meets as "incredible node", add them into the group of "artificial searching marker", delete all the nodes with this node as father node in OPEN list, and put them into barrier group to leaving out future search.

By using internal environmental search marker, the search efficiency is raised, and traps can be avoided. But this way is useless to marginal barriers. This paper applies ways basing on internal environmental search marker which sets artificial barriers at external environment to meet the condition of internal barrier-adding, and thus divides marginal barriers into four categories as up, down, left, and right.

The third step is the optimization of feasible path. The improved feasible path of A* algorithm can be shown as Figure 4.

In the search process of A* algorithm, when meets barriers, the circulating direction will first be judged. If the estimator function is not suitable, then on the condition of the smallest estimator of n's expand nodes being the same, a node n+1 will be randomly chosen, and the next expand node n+2 may not be the node on best path which will leads to the wrong choice of best path. Therefore, optimization on the feasible paths is very necessary. On the premise of now interfering the "closing" state of barrier and the efficiency in search process, add consciously the artificial search marker into environmental barriers, do repeated research to find a better path, compare all the path with the previous one after the search, and stop if the result is the same, continue if not.

6. Conclusion

However, coming back to preceding two problems about the visual sense of virtual human in virtual scene, there may be some other embodiments or objects with aggressiveness and purposeful mobility in certain range, and new conditions may appear in embodiment of virtual human's moving from A to B. So A* algorithm need to be improved by add extra cost to those certain positions and ranges in virtual environment. And going further, virtual human's evaluation from affection should be considered in constructing evaluation function H. Virtual human's Affective evaluation should be added to each step of the whole evaluation and option process in order to arrive at the same goal point from more flexible, comprehensive and humanized optimal path.

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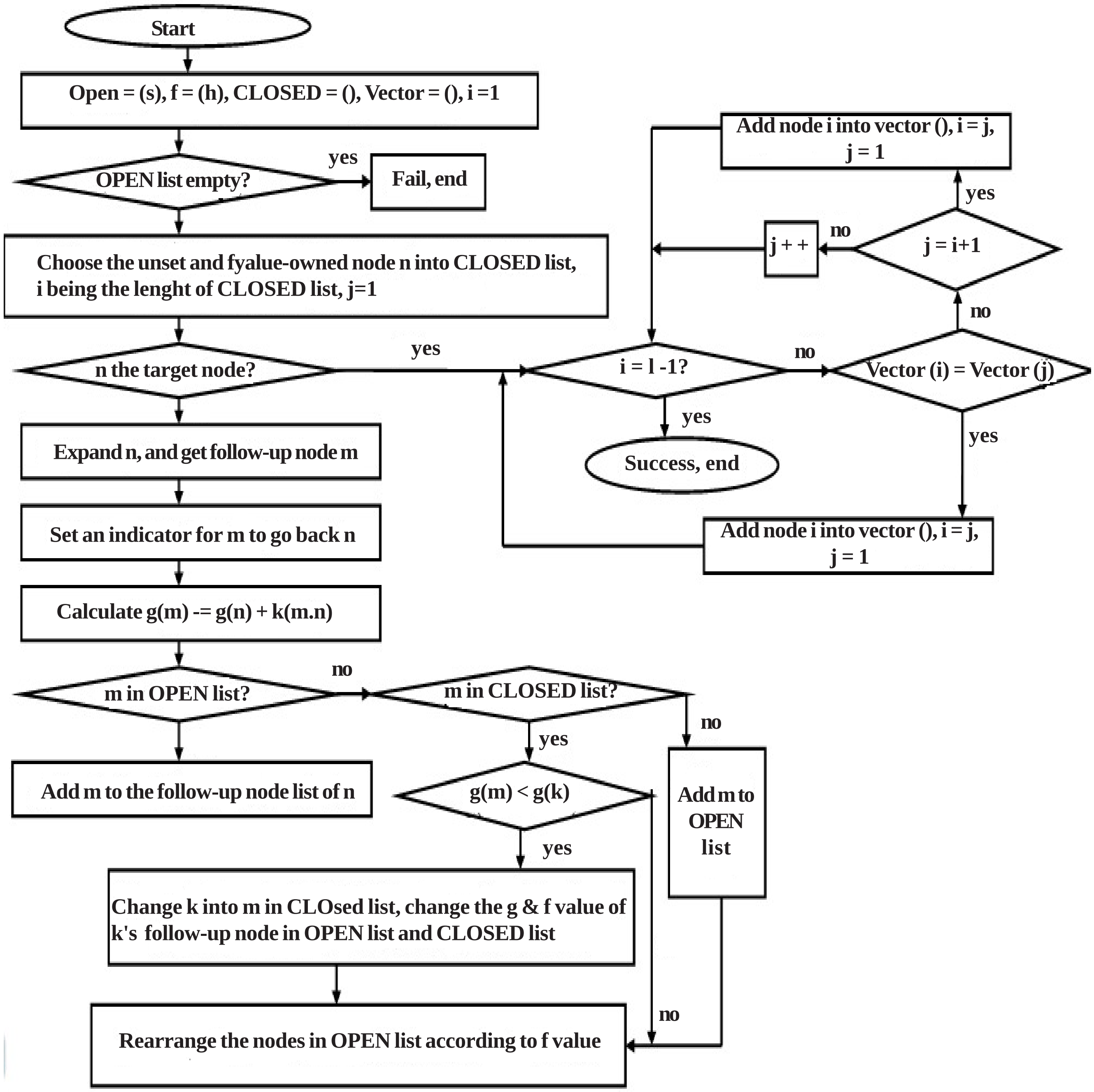

Figure 4. Flow Chart of Improved A* Algorithm

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