Real Time Virtual Animation Reconstruction Algorithm Based on Perception of Random Human Behavior and Collision Prediction

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Abstract —In order to expand the application of virtual reality technology in network, game, agriculture, industry and other fields, the generation and reconstruction of virtual animation has been deeply studied. However, under the impact of virtual human randomness and human behavior collision, there are the challenges of reliability and real time in the virtual animation. First of all, the model of human behavior is completed by the cooperation of scene perception, brain control and body movement. The initiation, process, and the depth of human behavior are fused to a behavior perception system. Then, the independent sensing vector, the random behavior response capture vector, and the random collision behavior detection vector are deployed in each position of the random person body. At the same time, the random human behavior collision prediction and coordination indicator vector are deployed, and the vector deployment architecture and animation generation system are proposed. Finally, the simulation experiments of MATLAB and visual C++, proved the superiority of the proposed virtual animation collision reconstruction algorithm in prediction accuracy, execution time, virtual behavior judgment accuracy and excellent performance of virtual animation reconstruction effect etc.

Index Terms—virtual animation reconstruction, random human, random behavior, collision prediction, behavior perception

I. Introduction

A variety of virtual human animations in the animation [1], online games [2], film and television special effects [3] and virtual agriculture [4] have been widely promoted and applied. By combining the virtual reality, behavior recognition, digital cognition and virtual network, the research on the generation of virtual animation has received more and more attention [5]. Here, one of the most critical technologies was the generation and reconstruction of the human's random behavior and the animation of the [6]. Real time generation and reconstruction of virtual animation considered the stochastic modeling, random behavior detection [7], behavior collision detection, virtual behavior perception and so on.

First, article [8] showed the step on the path back to a concept of man as autonomous and away from the concept of man as automaton. Findings of article [9] thought the parent stigma should be considered in the design of care models to ensure that children receive needed preventative and treatment services for behavioral health problems in African American families. The results of article [10] suggested that semantic information about motion retrieved in language regions may automatically modulate perceptual decisions about motion.

Second, article [11] presented a method of collision predictions for external beam radiotherapy using surface imaging. Article [12] analyzed the collected data to find the changes in pedestrian density and speed, percentage of children, and pedestrian trajectories. Article [13] summarized the factors that influence perception risk and discussed the direction of these relationships and conclude with presenting limitations of this review and an outlook on future research.

Then, article [14] proposed a novel approach to the treatment of animation deformity in cases of reconstruction, whereby the pectorals major muscle is sutured down to the chest wall and the implant is transferred to the subcutaneous plane. Article [15] presented a method for reconstructing a surface mesh animation sequence from point cloud animation data.

Therefore, based on the modeling, collision detection, and virtual human behavior random behavior research of virtual animation real-time generation and reconstruction problems, we conducted the in-depth study and gave a reliable reconstruction of the feasible scheme of virtual animation.

The rest of the paper is organized as follows. Section 2 describes the virtual animation model based on the random human behavior perception. Section 3 described the virtual animation reconstruction scheme with collision prediction. Section 4 gives the analytical results of the proposed algorithm. Finally, Section 5 concluded the paper.

II. Virtual Animation Model with Random Human Behavior Perception

The random behavior of human is completed by the cooperation of scene perception, brain control and body movement. The random behavior of human has the

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unpredictable characteristic. The various stages of stochastic behavior are implemented by the context of the nervous system and the interaction between the bodies. The initiation, transition, and completion of a human behavior form a fusion behavioral perception system. In order to realize the animation modeling of human random behavior, the distributed modeling and interactive integration of behavior sensing system become the most complex and key problem.

Stochastic human behavior perception and control model can realize distributed modeling and interactive fusion through human self-sensing, random behavior response and behavior detection. In order to provide accurate virtual animation data and eliminate excessive redundancy, we must achieve a high degree of unified scheduling and deep fusion. The stochastic behavior perception and control model could reduce the complexity of human behavior. The functional description of each functional module and the relationship between the random human behavior and perceptual scheduling are described as follows.

The intelligent behavior of random people and cognition knowledge are the important factors. Random behavior initiated the distributed response of the perception of the scene, the brain control and the body movements of the individual modules. The autonomous perception of random person is responsible for the operation of scene perception, brain control and body movement. The scheduling can reduce the control precision of the stochastic behavior and the working efficiency of the optimized behavior sensing module. Based on the research results of understanding and shaping original animation roles [16], the interaction between autonomous perception and behavior scheduling can effectively deal with the initiation process of stochastic behavior, as shown in Fig. 1.

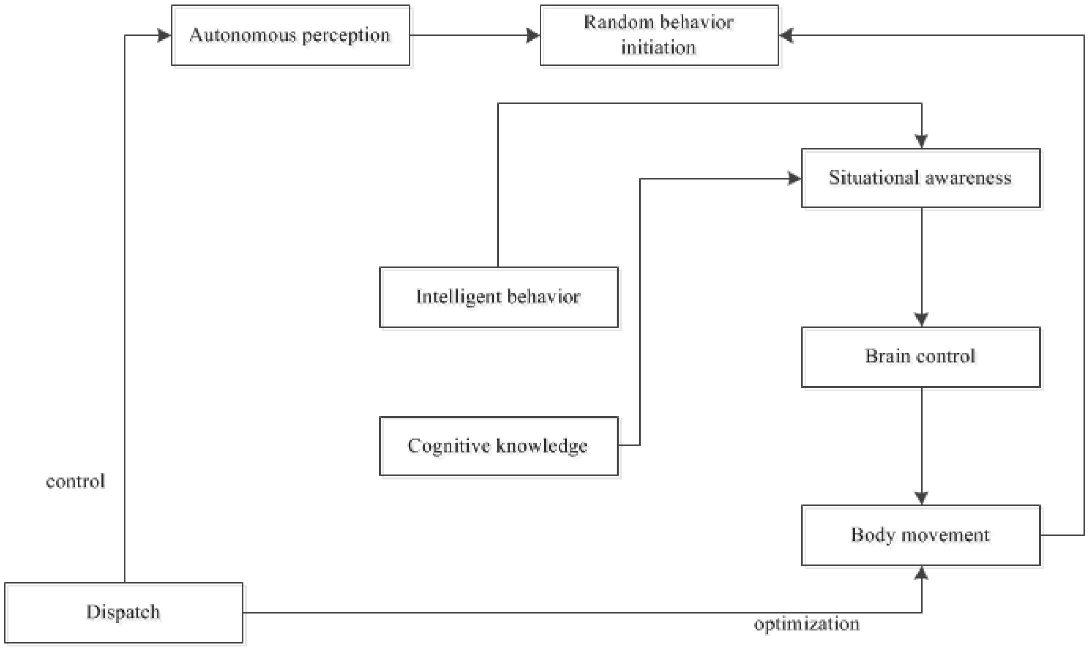

Fig. 1. Interaction between autonomous perception and behavior scheduling.

Due to the difficulty of behavior detection and large response delay in the implementation of the distributed scheduling, the stochastic behavior response and random human scheduling model are proposed in the process of the random human behavior. The random behavior of the discrete random behavior is fused to a depth relationship. The whole scheme can provide a direct mapping relationship between behavior response and induction scheduling. Stochastic behavior in response improve the stochastic scheduling. Scheduling information is fed back to each module of the response of a given behavior. Each response module generates a set of random human behaviors with a certain complexity by matching the body coordination and the behavior response.

The autonomous perception and behavioral response delay depend on the complexity of a set of random human behavior. Therefore, the complexity of stochastic complexity is analyzed by means of behavior detection. Through the coordination of the various modules, the delay would be reduced and the stability of the random behavior would be improved.

The perception accuracy of random human behavior is directly related to the people self-perception. The relationship is affected by the delay and the response scale of the random behavior detection. The perceptual complexity of random human behavior and the mapping of virtual animation are influenced by human body coordination and space physics. Therefore, it is divided into the following three kinds of behavior perception and control.

1) The intrinsic behavior. This behavior is determined by autonomous perception and situational awareness. This behavior is the innate character of virtual human. This behavior is expressed as MV_S (AP>w_a, SA). AP

indicates the complexity of the autonomous perception. *SA* represents context aware data size. Parameter w_a represents the threshold value of behavior perception.

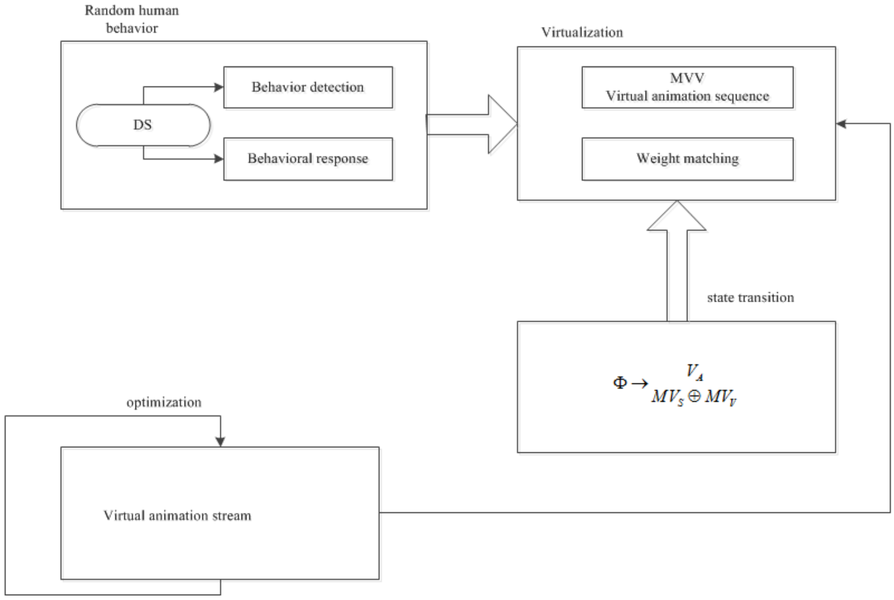

Fig. 2. State transition process of virtual animation.

2) Random behavior. The behavior is initiated by random people and randomly generated by the control of the brain. This behavior can reflect the behavior attributes and characteristics of virtual human. This behavior is easy to build animation model for virtual human. This behavior is expressed as MV_R (*AP*, *SA*, *BC*>w_b). Among them, *BC* said the depth of the brain control. *WB* expression behavior detection and control coefficient.

3) Virtual behavior. The behavior is composed of the micro motion of the body movement. This behavior captures the relevant information through behavior detection and random behavioral response. This behavior is the basis of the data source and behavior prediction of virtual animation. This behavior is expressed as MV_V (*AP*, *SA*, *BC*>w_b & *DS*>w_c). Among them, *DS* represents a collection of virtual animation data sources. Parameter w_c represents the minimum data set size required to implement a virtual animation.

To sum up, the virtual animation model of random human behavior perception through the data source *DS*, brain intelligent control weights *BC* and body virtual micro behavior set depth integration. The establishment speed of the virtual animation model is shown in the formula (1).

$$\begin{cases} G_R = \dfrac{MV_V}{MV_R} \oplus MV_S \cdot \min\left\{DS, w_c\right\} \\ MV_V = \max\left\{\dfrac{MV_V}{AP_R}, w_c\right\} \\ MV_R = \max\left\{\dfrac{MV_R}{AP_V}, w_b\right\} \end{cases} \tag{1}$$

Here, G_R represents the speed of virtual animation. All of the behavior are considered in the virtual animation data. The random behavior and the virtual behavior need to be compared with the threshold, and the maximum value is taken. So that it is convenient to optimize the modeling of virtual animation and reduce the complexity of the data.

The state vector *VA (DS)* of the virtual animation model is shown in the formula (2). By taking the minimum value of w_a, w_b and w_c, the data of the each random person behavior is analyzed.

$$VA(DS) = G_R \sum_{i=1}^{\min(w_a, w_b, w_c)} DS_i \cdot MV_V\left(AP, SA, w_b, w_c\right) \tag{2}$$

As shown in Fig. 2, the state of virtual animation transferred with the random behavior of the test in accordance with the formula (3). The state vector the formula (2) are the calculation object of Formula (3).

$$\Phi = \begin{bmatrix} VA_0 & VA\left(DS_{n/2}\right) & VA_n \\ 1 & w_b & MV_S \oplus MV_V \\ 0 & 0 & VA\left(DS_{n/2}\right) - VA\left(DS_1\right) \end{bmatrix} \tag{3}$$

Here, VA_0 said that the random behavior of the initial stage of behavior detection vector. Symbol *n* represents the size of the virtual animation data source.

III. Virtual Animation Reconstruction Algorithm with Collision Prediction

On the basis of the virtual animation model, the following vectors are set up in each part of the body. They include autonomous perception vector, random behavior initiated scheduling instruction vector, random response vector capture, and collision induced scheduling instruction of the random vector coordinate forecast random collision behavior detection and collision indicator vector. The symbols, characteristics and functions of the above vectors are described in Table I. The vector deployment architecture and animation generation system used in the virtual animation model of the random person are shown in Fig. 3.

TABLE I: RANDOM HUMAN BEHAVIOR DETECTION VECTOR MODULE

Behavior detection module	symbol	function	characteristics
Autonomous perception vector	V_{AP}	Active perception of the behavior of random people	Vector included angle 0.06; Self-perceived weight 0.2; Vector update period 1ms
Random behavior initiated scheduling instruction	IV_{RBS}	Limb movement initiation behavior awareness	Instruction cycle 1ms; Indicator accuracy 80%
Random behavior response capture vector	VR_{BC}	Capture random behavior and send a collision warning signal to the neighbor	Vector included angle 0.1; Capture cycle 2ms; Vector update period 2ms
Random human collision induced scheduling indicator vector	IV_{CS}	Induced stochastic behavior collision. Issue a collision dispatch command	Instruction cycle 1ms; Indicator accuracy 85%
Random collision behavior detection	V_{CD}	To detect the collision behavior of random people.	Collision angle 1; Collision detection weight 0.7; Vector update period 1.5ms
Coordinated indicator vector for collision prediction	IV_{CP}	By coordinating the virtual behavior of random people and coordinating animation reconstruction	Instruction cycle 1ms; Indicator accuracy 85%; Coordinate weight 0.8

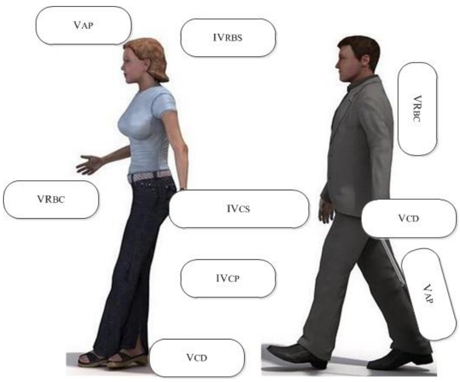

Fig. 3. Vector deployment system used in the virtual animation model of random person.

By deploying all kinds of vectors on the virtual model of the random person, the 3D geometric data of the virtual animation is captured to describe the behavior of the random people. By setting the vector angle, the detection period and the weight of the different vectors, the complex behavior of the random person and the free 3D representation of the virtual animation can be completely defined. According to the vector values mentioned in Table I, the different virtual behaviors can be compared, which control the random behavior of targets and the surface curve can get the attribute of the virtual animation better than the traditional method. The system described in Fig. 3 can create a more realistic, vivid virtual animation modeling and accurate behavior impact prediction. The vector polynomial function V_P of the random human behavior is shown in the formula (4).

$$V_P(k)=\frac{\sum_{i=0}^{m} VR_{BC}(i)\cdot V_{AP}(k)\cdot V_{CD}(i)}{\sum_{j=0}^{r} IV_{RBS}(k)\cdot IV_{CS}(j)\cdot IV_{CP}(j)} \tag{4}$$

Here, k represents a virtual behavior of a random person. Symbol m represents the number of a random person virtual behavior. Symbol i represents the number i virtual behavior. Symbol r represents the virtual collision number of random people. Symbol j represents the number j virtual collision behavior.

The reconstruction function of virtual animation after the continuous collision of random man is shown in the formula (5).

$$\begin{cases} V_P(k)=VR_{BC}(k)V_P(k-1), \quad q=1 \\ B_P(q)=\dfrac{\sum_{i=0}^{\min(m,q)} VR_{BC}(i)V_{CD}(i)}{V_P(q-1)}V_P(q)+ \\ \quad \sum_{j=0}^{\max(r,q)} IV_{CS}(j)\cdot IV_{CP}(j), \quad q\geq 2 \end{cases} \tag{5}$$

Here, the symbol q indicates the virtual behavior collision frequency. From the formula (5), it is found that there is a current direct impact on the future of the collision. According to this kind of direct relation, the virtual animation can be reconstructed by the virtual collision behavior.

The state of virtual animation changes with the collision behavior of random people. The state transition matrix $\overline{\Phi}$ of the reconstructed virtual animation is in the formula (6).

$$\overline{\Phi}=\begin{bmatrix} V_{AP} & VR_{BC}\left(\dfrac{n}{2}\right) & VA_{\min(m,r)} \\ 1 & w_b & MV_V \\ V_P\{q=1\} & B_P\{q\geq 2\} & IV_{CS}\cdot V_{CD} \end{bmatrix} \tag{6}$$

IV. PERFORMANCE ANALYSIS OF ANIMATION RECONSTRUCTION ALGORITHM

In order to verify the accuracy of collision prediction and the reconstruction performance of virtual animation, the motion data and behavior type of the proposed algorithm are analyzed in Table II. The number of virtual persons is random. It maybe 1, 2, 3, or 4. Motion data are obtained by using the 3DMoCap motion capture analysis system acquisition. The smoothing data sequence are removed from the collected data. We choose the severe motion data to validate the method. The virtual behavior sequence contains frame with time delay length 2 seconds and 5 seconds. These motion data contain a variety of types of noise interference and distortion data. Virtual behavior type covers the jogging, run, small jump, large jump, 90 degree turn, four limbs, etc.

The implementation of the proposed algorithm system development environment using the virtual reality and virtual graphics function programming in Visual Studio 2010. At the same time, the powerful function of MATLAB and Simulink are used to complete the three-dimensional entity position, angle, virtual animation modeling and other tasks. The development platform of the proposed algorithm is implemented to capture the data acquisition and processing of the random behavior of the proposed algorithm. The platform has the input and output of virtual behavior to capture data and the generation and reconstruction of 3D virtual animation. Reconstruction data for virtual animation can be displayed in time domain and spatial domain. The platform can be used to analyze and evaluate the reconstructed data of virtual animation. The operating system of the platform is Windows 7. The hardware environment is compatible with PC. Configuration for the 4 core processor, clocked at 2.5GHz. Memory for 4GB.

In the above system, we compared the proposed VAR-PRCP (Real time Virtual Animation Reconstruction algorithm based on Perception of Random human behavior and Collision Prediction) algorithm and the virtual animation reconstruction algorithm based on content driven collision warning denoted as VAR-CCW with the impact prediction accuracy, behavior decision precision, virtual animation reconstruction precision and algorithm execution time.

TABLE II: MOVEMENT DATA AND BEHAVIOR TYPES

Parameters	Jogging	Run	Small jump	Large jump	90 degree turn	Four limbs
Total frames	200	150	180	220	120	90
Frequency of occurrence (fames/s)	50	50	60	60	40	35
Total processing time(ms)	1450	1450	1580	1580	1200	2200
Mapping frequency (%)	78	87	88	90	90	75
Noise power spectral density (dBm/Hz)	[-50, 0]	[-50, 0]	[-50, 0]	[-50, 0]	[-50, 0]	[-50, 0]
Continuous distortion frames (frames)	5	5	6	6	8	5
Maximum jitter delay (ms)	0.2	0.2	0.05	0.05	0.15	0.25
Behavior collision probability (%)	1	1	2	2	2.3	5

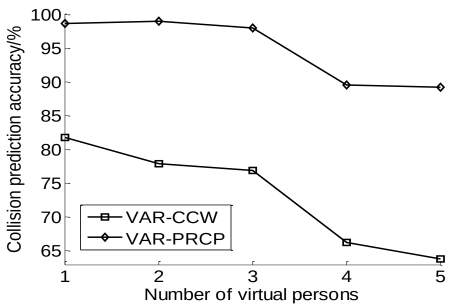

Fig. 4. Collision prediction accuracy.

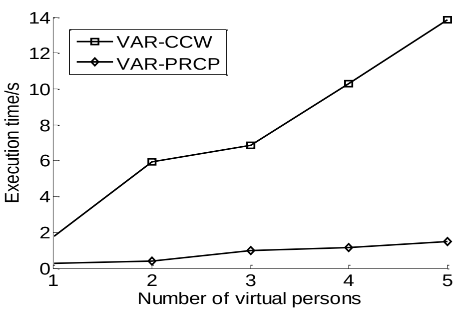

Fig. 5. Execution time.

Fig. 4 shows the collision prediction accuracy of the two reconstruction algorithms. It is found that the VAR-CCW algorithm is only concerned with the behavior of the content, ignoring the randomness, so the collision prediction accuracy is lower than that of the proposed VAR-PRCP algorithm. Moreover, VAR-PRCP algorithm achieves a high degree of unified scheduling and deep fusion by sensing the virtual animation data and eliminating excessive redundancy. In addition, the proposed VAR-PRCP algorithm can reduce the complexity of random behavior by using the random human behavior perception and control model. The proposed VAR-PRCP algorithm has a functional division and a random human behavior coordination scheduling for the collision of various kinds of behavior, which significantly improves the prediction accuracy of collision in the multi person environment.

Fig. 5 shows the execution time of the two reconstruction algorithms. As the number of random people increases, the execution time of virtual animation is gradually increased. However, the proposed VAR-PRCP algorithm is adopted to detect and respond to the minimum weight of the random person, and the data is processed by the virtual process. The proposed VAR-PRCP algorithm realizes the state transition process of virtual animation. Therefore, the proposed VAR-PRCP algorithm can solve the problem of multi person environment behavior detection and virtual animation reconstruction.

Fig. 6 shows the error of detection and decision for the virtual behavior of jogging, running, small jumps, large jumps, 90 degree turn, 180 degree turn, and other types of limbs. The proposed VAR-PRCP algorithm set up autonomous perception vector in various parts of the body were the random behavior initiated scheduling instruction vector, random response vector capture, collision induced scheduling instruction of the random vector coordinate forecast random collision behavior detection and collision indicator vector. Therefore, the proposed VAR-PRCP algorithm can grasp the characteristics of random human behavior in real time and reconstruct the data required by the virtual animation. The proposed VAR-PRCP algorithm based on random human virtual animation model through the virtual human detection vector system to achieve high accuracy of the behavior of the decision and the high accuracy of the virtual animation, as shown in Fig. 7.

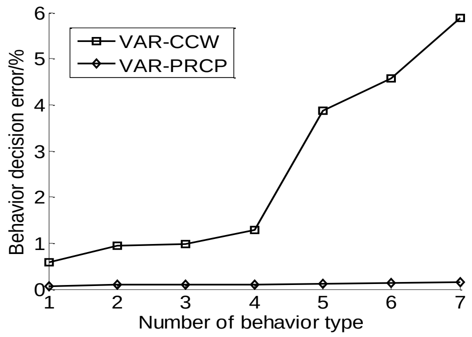

Fig. 6. Behavior decision error.

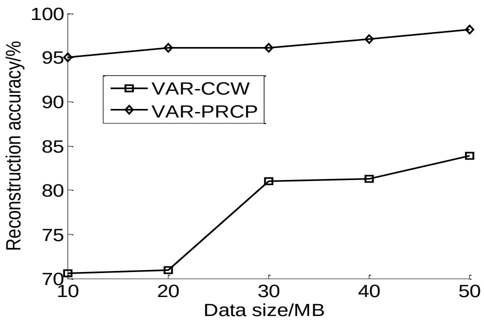

Fig. 7. Reconstruction accuracy.

V. Conclusions

Virtual reality technology can be extended to wireless virtual network, virtual game, virtual agriculture and virtual industry through the generation and reconstruction technology of virtual animation. Among them, how to improve the reliability and real-time performance of the application in the field of virtual animation has become the bottleneck of technology extension. In order to solve these problems, this paper proposed a real time virtual animation reconstruction algorithm based on random human behavior perception and collision prediction. On the one hand, it established the model of the virtual human scene perception, the brain control and the body movement. On the other hand, the behavior of the virtual human was detected and controlled by the deployment of the autonomous perception vector, the vector of the random behavior response, and the detection of the random collision behavior. By predicting the behavior of random human collision and coordinating the virtual animation model, the virtual animation system based on the vector detection system is studied. The simulation experiment of MATLAB and visual C++, the prediction accuracy, behavior recognition ability, efficiency and other aspects of the effect of reconstruction were compared. Compared with the virtual animation reconstruction algorithm by driving collision warning content, the proposed algorithm has obvious advantages.

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