DYNAMIC PIVOT POINT TECHNIQUE (DYOP) IN NARROW-PHASE COLLISION DETECTION

HAMZAH ASYRANI SULAIMAN

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(Tandatangan Pustakawan)

PROF. MADYA DR. ABDULLAH BADE
Penyelia

SUPERVISOR'S DECLARATION

NAME : **HAMZAH ASYRANI SULAIMAN**

MATRIC NO. : **PS20109094**

TITLE : **DYNAMIC PIVOT POINT TECHNIQUE (DYOP) IN NARROW-PHASE COLLISION DETECTION**

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DATE OF VIVA **12 JANUARY 2015**

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1 August 2015

Hamzah Asyrani Sulaiman
PS20109094

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ABSTRACT

Contact determination between nearly colliding objects is one of the crucial issues in virtual environment simulation particularly for collision detection system such as in medical simulation, computer games, and engineering visualization. The contact determination technique consists of distance computation, point of contact and depth penetration phase. It requires information of object direction towards other object that moves in opposite direction namely intersection. The main problem in this research is to study a nearly accurate distance approximation computation caused by heavy calculation that deteriorating speed and efficiency of collision detection system. This thesis aims to introduce an agile and new technique for contact determination in narrow phase collision detection that increases speed and improves the efficiency of narrow phase collision detection. The proposed narrow phase collision detection technique in this study consists of distance computation method, point of contact between nearly collided object and depth penetration method namely Dynamic Pivot Point (DyOP). The technique enables numbers of testing to be reduced as compared to the prominent techniques such as Lin-Canny and GJK technique. The proposed technique starts by first identifying the nearest triangle of corresponding objects that is going to be intersected with another triangle that are bound with an Axis Aligned Bounding-Box (AABB). Then, we need to find the parallel line distribution created by each axis of AABB for each triangle. Next, an internal intersection using internal AABB by using maximum and minimum parallel line distribution of each object. A pivot point called DyOP will be calculated as a reference point to the contact determination technique. The proposed technique is able to reduce nine vertices testing down to six vertices testing and nine vertex-edge testing's down to only two vertex-edge testing's. Three sets of testing have been conducted to evaluate and verify the proposed technique with two other prominent techniques. The first test was conducted by investigating time execution of ten different triangles with pre-defined size but vary in distance computation phase. Based on the experiments, out of 90 concurrent testing's, the proposed technique managed to achieve 187.3% improvements with the fastest execution time about 55 milliseconds. The subsequent test was conducted with the point of contact phase. Based on the experiments conducted, the proposed technique successfully attained 79.05% improvement with an average of 7.6 milliseconds and almost similar to Lin-Canny technique for point of contact. The final test to determine depth penetration, the technique managed to achieve 53.63% better improvement and an average of 10.75 milliseconds per test with similar accuracy. The results from the experiments showed that the DyOP technique is efficient to perform contact determination in narrow phase collision detection and increase the speed of distance computation, point of contact and depth penetration by reducing the number of testing. These indicated that, the DyOP technique is efficient, accurate and robust not only to the tested environment but other unprepared environment and could be adapted to any desired target area or domain.

ABSTRAK

TEKNIK TITIK PIVOT DINAMIK (DYOP) DALAM PENENTUAN PERLANGGARAN UNTUK FASA GENTING SISTEM PENGESANAN PERLANGGARAN N-BADAN

Penentuan perlanggaran antara objek yang hampir berlanggar adalah salah satu isu kritikal dalam simulasi persekitaran maya untuk sistem pengesanan perlanggaran hampir tepat seperti dalam simulasi perubatan, permainan komputer, dan visualisasi kejuruteraan. Teknik penentuan perlanggaran terdiri daripada pengiraan jarak, penentuan titik perlanggaran dan fasa penentuan kadar penembusan kedalaman. Ia memerlukan maklumat arah objek yang akan berlanggar bergerak ke arah satu lagi objek yang bergerak ke arah yang bertentangan yang mewujudkan satu perlanggaran. Masalah wujud apabila satu anggaran jarak yang dikira dalam cara yang rumit mungkin mengurangkan kelajuan dan kecekapan laporan perlanggaran. Tesis ini bertujuan untuk memperkenalkan teknik baru untuk penentuan perlanggaran dalam fasa teliti untuk pengesanan perlanggaran yang meningkatkan kelajuan dan kecekapan jarak pengkomputeran, titik hubungan antara objek hampir bertembung dan penentuan kadar penembusan kedalaman dengan melaksanakan teknik Titik Asalan Dinamik (DyOP). Ia membolehkan bilangan ujian dikurangkan berbanding kaedah konvensional Lin-Canny dan Gilbert-Keerthi–Johnson (GJK). Teknik ini bermula dengan menentukan segitiga yang terdekat dengan objek yang akan bertembung dengan segi tiga lain yang disempadani dengan Ruang Lingkup Tertutup (AABB) yang sepadan. Berdasarkan maklumat di atas, kita perlu mencari garis persempadanan yang dihasilkan oleh setiap AABB. Setelah menentukan garis persempadanan tersebut, kita akan mewujudkan satu AABB dalaman yang menggunakan maklumat garis persempadanan maksimum dan minimum oleh kedua-dua AABB yang hampir bertembung ini. DyOP akan dikira sebagai titik rujukan yang akan menentukan dan membantu mendapatkan maklumat perlanggaran. Teknik kami dapat mengurangkan sembilan ujian titik bucu ke enam bucu dan sembilan ujian bucu-garis tepi turun ke hanya dua ujian bucu-garis tepi. Tiga set ujian telah dijalankan untuk menilai dan mengesahkan teknik yang dicadangkan dengan dua teknik biasa iaitu Lin- Canny dan GJK. Ujian pertama dijalankan dengan menentukan masa perlaksanaan untuk sepuluh jenis segitiga yang telah diisytiharkan untuk kegunaan eksperimen yang juga berlainan saiz antara satu sama lain. Berdasarkan eksperimen yang melibatkan 90 simulasi perlanggaran serentak, teknik kami berjaya mendapatkan peningkatan sebanyak 187.3% dengan masa terpantas iaitu 55 milisaat. Ujian kedua pula merujuk kepada fasa penentuan titik perlanggaran antara dua segitiga ini. Teknik kami berjaya mendapatkan peningkatan sebanyak 79.05% dengan masa terpantas iaitu 7.6 milisaat dengan titik perlanggaran yang hampir sama dengan teknik yang lain sehingga lima tempat perpuluhan. Ujian terakhir adalah melibatkan penentuan kadar penembusan kedalaman di mana sebanyak 53.63% peningkatan dicapai dengan masa terpantas sebanyak 10.65 milisaat secara purata. Dari eksperimen yang dijalankan, teknik DyOP berupaya meningkatkan keupayaan penentuan fasa teliti perlanggaran objek dan meningkatkan kelajuan penentuan jarak perlanggaran, penentuan titik perlanggaran dan seterusnya kadar penembusan kedalaman objek berlanggar. Ini menunjukkan bahawa keknik DyOP kami adalah cekap, tepat dan mantap bukan sahaja kepada persekitaran yang diuji tetapi persekitaran simulasi yang lain dan boleh menjadi mudah alih kepada mana-mana kawasan sasaran yang diingini.

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