

HYBRID BEHAVIOR TREE AND FINITE STATE MACHINE IMPLEMENTATION FOR HUNTER NPC IN *JALAK BALI SURVIVE* GAME

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ABSTRAK

Kecerdasan Buatan (AI) memainkan peran penting dalam mengendalikan perilaku Karakter Non-Pemain (NPC) dalam permainan video. Dalam penelitian ini, teknik Hybrid FSM-Behavior Tree (Hybrid FSM-BT) diusulkan untuk meningkatkan kemudahan pemeliharaan, modularitas, dan skalabilitas dalam pengendalian perilaku AI. Untuk mengevaluasi efektivitas pendekatan yang diusulkan, perbandingan dilakukan dengan dua teknik pengendalian AI yang umum: Standalone Behavior Tree (BT) dan Finite State Machine (FSM). Teknik Hybrid FSM-BT dan metode perbandingan diimplementasikan dalam proyek permainan Jalak Survive, di mana NPC pemburu melakukan berbagai tindakan seperti patroli, memasang jebakan, berburu, dan menangkap burung. Kemudahan pemeliharaan dan kompleksitas kode diukur menggunakan Microsoft Visual Studio's Code Metrics, termasuk Indeks Kemudahan Pemeliharaan, Cyclomatic Complexity, Ketergantungan Kelas, dan Jumlah Baris Kode. Keabsahan fungsional diverifikasi menggunakan pengujian Black Box dan White Box. Selain itu, pengalaman pengguna dievaluasi melalui Game Experience Questionnaire (GEQ). Analisis menunjukkan bahwa Hybrid FSM-BT mencapai Indeks Kemudahan Pemeliharaan yang lebih tinggi (66) dibandingkan Standalone BT (46), meskipun FSM mencapai skor tertinggi (79). Namun, FSM juga menunjukkan Cyclomatic Complexity yang jauh lebih tinggi, menunjukkan tantangan yang lebih besar dalam pengujian dan debugging seiring meningkatnya kompleksitas sistem. Hybrid FSM-BT, melalui state-based organization dan Tree perilaku modular, menyediakan solusi yang lebih seimbang yang mendukung debugging yang lebih mudah, skalabilitas yang lebih baik, dan perluasan fitur di masa depan. Evaluasi pengalaman pengguna juga menunjukkan bahwa pemain umumnya menikmati permainan, melaporkan tingkat kompetensi dan kesenangan yang tinggi, serta tingkat frustrasi yang rendah. Kesimpulannya, teknik Hybrid FSM-BT menawarkan keunggulan signifikan untuk sistem AI yang diharapkan akan semakin kompleks, dengan struktur yang skalabel, modular, dan dapat dipelihara, sambil mempertahankan keakuratan fungsional dan pengalaman pemain yang positif.

Kata kunci : Finite State Machine, Behavior Tree, NPC, Pengembangan Game, Video Game.

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ABSTRACT

Artificial Intelligence (AI) plays an essential role in controlling Non-Player Character (NPC) behavior in video games. In this research, a Hybrid FSM-Behavior Tree (Hybrid FSM-BT) technique is proposed to improve maintainability, modularity, and scalability in AI behavior control. To evaluate the effectiveness of the proposed approach, comparisons were conducted against two common AI control techniques: Standalone Behavior Tree (BT) and Finite State Machine (FSM). The Hybrid FSM-BT and comparison methods were implemented within the game project *Jalak Survive*, where an NPC hunter performs various actions such as patrolling, setting traps, hunting, and capturing birds. Maintainability and code complexity were measured using Microsoft Visual Studio's Code Metrics, including Maintainability Index, Cyclomatic Complexity, Class Coupling, and Lines of Code. Functional correctness was validated using Black Box and White Box testing. Additionally, user experience was assessed through the Game Experience Questionnaire (GEQ). The analysis showed that the Hybrid FSM-BT achieved a higher Maintainability Index (66) compared to Standalone BT (46), though FSM achieved the highest score (79). However, FSM also demonstrated significantly higher Cyclomatic Complexity, indicating greater challenges in testing and debugging as system complexity increases. The Hybrid FSM-BT, through its combination of state-based organization and modular behavior trees, provided a more balanced solution that supports easier debugging, better scalability, and future feature expansion. The user experience evaluation also indicated that players generally enjoyed the game, reporting high competence and enjoyment, and low frustration levels. In conclusion, the Hybrid FSM-BT technique offers significant advantages for AI systems expected to grow in complexity, providing a scalable, modular, and maintainable structure, while maintaining functional correctness and positive player experience.

Keywords : Finite State Machine, Behavior Tree, NPC, Game Development, Video Game.