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Samenvatting

Zoeken & Her-zoeken Onderzocht

Dit proefschrift gaat over zoekalgoritmen. Zoekalgoritmen worden vaak aan de hand van hun expansie-strategie gekarakteriseerd. Een mogelijke strategie is de depth-first strategie, een eenvoudig backtrack mechanisme waarbij de volgorde waarin knopen gegenereerd worden bepaalt hoe de zoekruimte doorlopen wordt. Een alternatief is de best-first strategie, ontworpen om het gebruik van domein-afhankelijke heuristische informatie mogelijk te maken. Door veelbelovende wegen eerst te bewandelen, zijn best-first algoritmen in het algemeen efficiënter dan depth-first algoritmen.

Voor minimax spelprogramma's (zoals voor schaken en dammen) is de efficiëntie van het zoek algoritme van cruciaal belang. Echter, alle goede programma's zijn gebaseerd op een depth-first algoritme, niettegenstaande het succes van best-first strategieën bij andere toepassingen.

In dit onderzoek worden een depth-first algoritme, Alpha-Beta, en een best-first algoritme, SSS*, nader beschouwd. De heersende opinie zegt dat SSS* in potentie efficiënter zoekt, maar dat de ingewikkelde formulering en het exponentiële geheugengebruik het tot een onpraktisch algoritme maken. Dit onderzoek laat zien dat er een verrassend eenvoudige relatie tussen de twee algoritmen bestaat: SSS* is te beschouwen als een speciaal geval van Alpha-Beta. Empirisch vervolgonderzoek toont aan dat de heersende opinie over SSS* fout is: het is geen ingewikkeld algoritme, het gebruikt niet te veel geheugen, maar het is ook niet efficiënter dan depth-first algoritmen.

In de loop der jaren heeft onderzoek naar Alpha-Beta vele verbeteringen opgeleverd, zoals transpositietabellen en minimale zoekwindows met her-zoeken. Deze verbeteringen maken het mogelijk dat een depth-first procedure gebruikt kan worden om de zoekruimte op een best-first manier te doorlopen. Op basis van deze inzichten wordt een nieuw algoritme gepresenteerd, MTD(f), dat beter presteert dan zowel SSS* als NegaScout, de in de praktijk meest gebruikte Alpha-Beta variant.

Naast best-first strategieën behandelt dit proefschrift ook andere mogelijkheden om minimax algoritmen te verbeteren. In het algemeen wordt aangenomen dat geen enkel algoritme dat de minimax waarde wil vaststellen efficiënter kan zijn dan de best-case van Alpha-Beta – dit is de zogeheten minimale boom. In de praktijk is deze opvatting niet juist. De echte minimale graaf die de minimax waarde bepaalt blijkt aanmerkelijk kleiner te zijn dan Alpha-Beta's best-case. Dientengevolge is er meer ruimte voor verbetering van minimax zoekalgoritmen dan in het algemeen wordt aangenomen.

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