

UNIVERSITY OF TARTU
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Revising Fuzzy Genetic Algorithms: Rule Generation and a Cached Nearest-Neighbor Strategy

Master's Thesis (30 ECTS)

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Abstract:

Genetic algorithms (GA) can be more helpful in finding global minima/maxima than other methods, like gradient descent or random search, especially for nondifferentiable functions with lots of local minima and maxima. One of the drawbacks of standard GA methods is that lots of hyperparameters need to be set, and selection pressure is applied based on complex rules as opposed to more intuitive fuzzy rules. Variants of genetic algorithms that adjust such parameters via fuzzy logic, to make parameter update principles more interpretable, constitute the class of fuzzy genetic algorithms (FGAs).

This thesis proposes modifications to two relatively recent Fuzzy Genetic Algorithms (FGAs) with N-terms and auto-generated rules, along with a computational optimization aimed at improving simulation runtime. The modifications are evaluated on benchmark functions (Ackley, Griewank, Rastrigin, and Schwefel) and the best setting for each modified method is selected (i.e. membership functions, number of terms, t-norm and t-conorm). The outcome is compared to standard GA and particle swarm optimization (PSO). The results showed that FGA methods could be optimized using caching and nearest-neighbor methods without losing accuracy and convergence. Both of the modified (and unmodified) methods were shown to perform statistically significantly worse than the baseline methods. As a result, we have proposed two optimizations of the existing two algorithms: extrapolation with rule generation and nearest-neighbor estimate with caching and tested their performance.

Keywords:

Fuzziness, Metaheuristics, Fuzzy rules

CERCS: P170 Computer science, numerical analysis, systems, control

Hägasate geneetiliste algoritmide läbivaatamine: reeglite loomine ja vahemällu salvestatud lähima naabri strateegia

Lühikokkuvõte:

Geneetilised algoritmid (GA) võivad olla abiks globaalsete miinimumide/maksimumide leidmisel rohkem kui muud meetodid, nagu gradiendi laskumine või juhuslik otsing, eriti mittediferentseeruvate funktsioonide puhul, millel on palju kohalikke miinimume ja maksimume. Üks standardsete GA-meetodite puudusi on see, et tuleb määrata palju hüperparameetreid ja valikusurvet rakendatakse keerukate reeglite alusel, mitte intuitiivsematel ähmastel reeglitel. Geneetikaalgoritmide variandid, mis kohandavad selliseid parameetreid hägusloogika abil, et muuta parameetrite värskendamise põhimõtted paremini tõlgendatavaks, moodustavad hägasate geneetiliste algoritmide (FGA) klassi.

Selles lõputöös pakutakse välja kahe suhteliselt hiljutise N-termi ja automaatselt genereeritud reeglitega fuzzy genetic algoritmi (FGA) modifikatsioonid koos arvutusliku optimeerimisega, mille eesmärk on parandada simulatsiooni käitusaega. Modifikatsioone hinnatakse võrdlusfunktsioonidel (Ackley, Griewank, Rastrigin ja Schwefel) ning iga muudetud meetodi jaoks valitakse parim seade (st liikmelisuse funktsioonid, terminite arv, t-norm ja t-konorm). Tulemust võrreldakse standardse GA ja osakeste sülemi optimeerimisega (PSO). Tulemused näitasid, et FGA meetodeid saab optimeerida vahemällu salvestamise ja lähima naabri meetodite abil, kaotamata seejuures täpsust ja konvergentsi. Näidati, et mõlemad modifitseeritud (ja modifitseerimata) meetodid toimisid statistiliselt oluliselt halvemini kui algtaseme meetodid. Selle tulemusena oleme pakkunud välja kaks olemasoleva kahe algoritmi optimeerimist: ekstrapoleerimise reegli genereerimisega ja lähima naabri hinnangu koos vahemällu salvestamisega ning testinud nende toimivust.

Võtmesõnad:

Hägusus, metaheuristika, hägused reeglid

CERCS: P170 Computer science, numerical analysis, systems, control

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