**PRIMJENA METODA VJEŠTAČKE INTELIGENCIJE U ELEKTROENERGETSKIM SISTEMIMA**

**ELEKTRIČNA POSTROJENJA**ETF EEO EP 3670

Studenti:  
Adna Kulovac

Amina Buza

Faruk Selimović

Muhamed Hrnjičić

Nastavni ansambl:  
Doc. Dr Selma Grebović, dipl.ing.el.

MoE Vahid Helać, dipl.ing.el.

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**1 UVOD**

Pojavom računara dolazi i do pojave vještačke inteligencije, a naročito u posljednjih četrdeset godina, gdje dolazi do njene nagle ekspanzije, istraživanja i primjene. Ako posmatramo npr. industriju uočiti ćemo da su inteligentni sistemi njen neizostavni dio koji obavlja složene i zahtjevne zadatke, te donosi odluke na osnovu prethodno stečenog znanja.

Prema tome, vještačku inteligenciju možemo posmatrati kao sistem koji se ponaša inteligentno, samostalno donosi odluke, pohranjuje nova znanja i to sve s ciljem da u budučnosti donosi bolje i kvalitetnije odluke.

Inteligentni sistem je svaki sistem koji pokazuje sljedeče osobine:

* ponaša se kao prilagodljiv i usmjeren cilju
* modificira se na temelju iskustva
* koristi se velikim količinama znanja
* komunicira sa čovjekom prirodnim jezikom i govorom
* tolerira pogreške i nejasnoće u komunikaciji
* operabilan je i odgovara u stvarnom vremenu.

Kada se fokusiramo na elektroenergetski sistem uviđamo da se svaki objekat ili postrojenje mora pregledati, a količina takvih radnji koje se mogu automatizirati pomoću vještačke inteligencije je iznimno velika. Tradicionalne metode održavanja i nadgledanja opreme zahtijevaju značajna finansijska sredstva i zaposlenike sa velikom količinom znanja koji se znaju snaći u slučajevima poremećaja rada sistema. Također, pojedine nepravilnosti u radu i stanju opreme nije moguće uvidjeti niti na ovaj način jer se mogu dogoditi u periodu između dva intervala inspekcije opreme. Zbog prethodno navedenog, uvođenje i primjena vještačke inteligencije u elektroenergetskim sistemima je od velikog značaja , a predstavlja i iskorak u novo elektroenergetsko doba.

Prednosti primjene vještačke inteligencije u elektroenergetskim sistemima su:

* predviđanje i prevencija kvara
* povećanje pouzdanosti i raspoloživosti opreme
* smanjenje troškova održavanja
* održavanje prema stanju opreme.

Metode vještačke inteligencije koje će biti predstavljene u ovome radu su:

* ekspertni sistemi (engl. : Expert systems)
* umjetna neuronska mreža (engl. : Artificial neural network)
* neizrazita logika (engl. : Fuzzy logic)
* genetski algoritam (engl. : Genetic algorithm).

**2 METODE VJEŠTAČKE INTELIGENCIJE**

**2.1. Ekspertni sistemi**

Ekspertni sistem je inteligentni računarski program koji koristi znanje i postupke zaključivanja u procesu rješavanja problema i to takvih problema za koje je potreban visok nivo znanja, stručnosti i iskustva iz područja kojem je ekspertni sistem namijenjen. Naziv ekspertni sistem dolazi iz činjenice da se ovi sistemi ponašaju kao vrhunski stručnjaci, odnosno eksperti na području za koje su namijenjeni.

Ekspert je često neophodna osoba u mnogim organizacijama i javlja se pitanje zašto ga uopče pokušavati zamijeniti mašinom? Ekspertni sistem može biti koristan kao pomoć kada čovjek nije raspoloživ ili kao alat koji olakšava posao, radi sa većim stepenom formalizma koji isključuje mogućnost greške ili slabosti zbog ljudskog faktora.

Sa strane korisnika ekspertni sistem djeluje kao savjetnik u određenoj oblasti. S obzirom da sadrži znanje i iskustvo jednog ili više eksperata, takav sistem omogućuje korisnike da rješava određene probleme i dobija odgovore ili smijernice za djelovanje u određenim situacijama. a taj način, bez prisustva eksperta, korisnik može da zadovolji svoje potrebe konsultujući se sa ekspertnim sistemom.

Osnovu ekspertnih sistema čini softver koji modelira one elemente čovjekovog rješavanja problema za koje se smatra da čine čovjekovu inteligenciju (zaključivanje, prosuđivanje, odlučivanje na osnovu nepouzdanih i nepotpunih informacija, tumačenje svog ponašanja i sl.).

Izgradnja ekspertnog sistema podrazumijeva saradnju tima stručnjaka i sastoji se iz nekoliko faza i to:

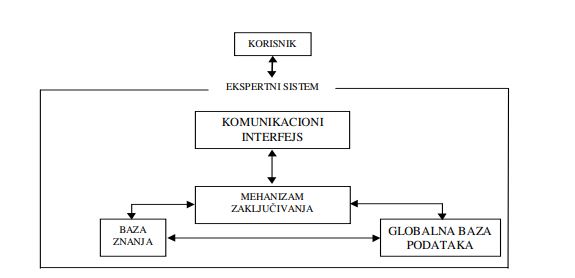
* idejni projekat sistema
* prikupljanje znanja
* razvoj sistema
* proračun performansi
* proračun prihvatljivosti
* demonstracije prototipa
* revizija i dalji ravoj
* realizacija sistema

Tim stručnjaka za izradu ekspertnih sistema uključuje razne profile kao što su:

* eksperti iz oblasti za koju se kreira ekspertni sistem
* stručnjaci koji prevode domensko znanje u adekvatan oblik predstavljanja koji je predviđen za funkcioniranje sistema
* stručnjaci koji konstruišu mehanizam zaključivanja i druge programe za komunikaciju sa korisnikom
* korisnici kojima je sistem namijenjen koji ukazuju na previde u prototipu i doprinose njegovom poboljšanju.

Glavne komponente ekspertnog sistema (slika 1.) su:

* baza znanja
* globalna baza podataka
* mehanizam zaključivanja
* komunikacioni interfejs.



Slika 1: Glavne komponente ekspertnog sistema

*Baza znanja* sadrži znanje iz predmetne oblasti i ona uključuje činjenice, relacije između činjenica i moguće metode rješavanja problema.

*Globalna baza* *podataka* je radna memorija za bilježenje trenutnih statusa sistema, ulaznih podataka za određeni problem i relevantnih elemenata iz dotadašnjeg rada. Razlikuje se od baze znanja po tome što sadrži informacije koje se odnose isključivo na tekući problem odlučivanja.

*Mehanizam zaključivanja* je softver sposoban da na osnovu pravila iz baze znanja shvati informacije iz baze znanja i na osnovu toga izvodi zaključke. On funkcioniše na način da činjenice iz baze znanja kombinuje sa informacijama dobivenim od korisnika u cilju izvođenja zaključaka. Pri radu se koriste kontrolne strategije koje odlučuju u kojem trenutku treba primijeniti neko od pravila iz baze znanja na nove činjenice dobivene tokom konsultacije sa korisnikom. Na ovaj način se simulira čovjekovo razmišljanje.

*Komunikacioni interfejs* je dio koji omogućuju korisniku da vodi dijalog sa ekspertnim sistemom, služi za unos i prikaz podataka, prezentuje moguće zaključke, prikazuje pitanja, odgovore i sl.

Prednosti primjene ekspertnih sistema su:

* prenosivost - Ekspertni sistemi se projektuju tako da mogu da prenesu znanja, dok to za jednog eksperta može biti težak, a ponekad i nerješiv problem. Ekspert je stručnjak za rješavanje problema, a ne zna objašnjavanje svojih odluka i prenošenje iskustva. Sa druge strane, ekspertni sistem se projektuje tako da ima mogućnost da objasni kako je došao do nekih zaključaka.
* postojanost - Vremenom sposobnosti eksperta opadaju jer čovjek stari, nije uvijek u mogučnosti da drži korak sa tehnološkim promjenama dok su mogučnosti ekspetrnog sistema nezavisne od vremena, emocija, zdravlja i sl.
* pouzdanost – Pri donošenju odluka, ekspert može biti pod uticajima okoline, može biti subjektivan. Ekspertni sistem za iste ulazne podatke uvijek donosi iste zaključke, na njega okolina ne utiče pa možemo reči da je on konzistentan.
* cijena – Ekonomski gledano cijena ekspertnog sistema je niska u poređenju sa izdacima za rad eksperta. Na poljima gdje je potrebno mnogo stručnjaka jeftinije je primijeniti ekspertni sistem. Također, lakše je obezbijediti više računara nego obučiti stručnjaka za neku oblast.

Prednosti čovjeka eksperta:

* kreativnost – Za nove probleme ekspert nalazi kreativna rješenja i u stanju je da se adaptira na promjene i novonastale situacije, dok ekspertni sistem može da rješava samo probleme iz uskog područja za koje posjeduje ograničeno znanje. Čovjek je u stanju da se uspješno snalazi u novim i nepoznatim situacijama, a ekspertni sistem za novu vrstu problema je neefikasan i često neupotrebljiv jer da bi mogao rješavati nove probleme prvo mu se mora proširiti baza znanja.
* zdrav razum – Racionalan čovjek se koristi zdravim razumom i u tome je racionalno ekspeditivan. Ako se pojavi nekakav nelogičan podatak, on će ga odmah uočiti i eliminisati iz daljeg razmatranja, dok ekspertni sistem mora da pretraži sve svoje podatke, da izgubi dosta vremena da bi na kraju utvrdio nekonzistentnost podatka.

Da bi razvoj ekspertnog sistema bio moguć, potrebni su sljedeći uslovi:

* rješavanje problema ne zahtijeva rasuđivanje zdravog razuma
* eksperti mogu da definišu metode rješavanja problema
* problem nije suviše složen
* problem je razumljiv

Razvoj ekspertnog sistema je opravdan ako:

* postoji ekonomska isplativost
* eksperti su rijetki ili često napuštaju radno mjesto
* radno mjesto je nepodesno ili štetno za čovjeka

U svijetu postoji veliki broj ekspertnih sistema, razvijenih u raznim oblastima ljudskih djelatnosti. Najviše ih je u medicini hemiji i vojnim naukama. U zavisnosti od tipa problema koje rješavaju, ekspertni sistemi se mogu razvrstati u nekoliko oblasti. Oblasti se preklapaju pa ih je ponekad nemoguće sasvim razdvojiti. Isto tako, postojeći ekspertni sistemi često rješavaju više tipova problema pa ih je teško jasno razdvojiti. Ipak, prema tipovima problema koje rješavaju, postoje sljedeće vrste ekspertnih sistema:

* sistemi za interpretaciju
* dijagnostički sistemi
* sistemi predviđanja
* sistemi projektovanja
* sistemi planiranja
* sistemi nadzora
* sistemi otklanjanja grešaka
* sistemi za učenje
* sistemi upravljanja.

**2.2 Genetski algoritam**

Genetski algoritmi su rezultat istraživanja John-a Holland-a.

Genetski algoritmi crpe ideju iz prirode, pogodni su za pretraživanje velikog prostora za najoptimalnijim rješenjem predmetnog problema. U zadnjih nekoliko godina genetski algoritmi su postali popularan način rješavanja složenih optimizacijskih problema zbog ljepote pristupa. Privlačan način rješavanja problema, simuliranjem ponašanja u prirodi, se može iskoristiti u cijelom nizu problema sa kojima se možemo susresti u stvarnom životu.

Holland je u svome radu predložio jednostavni genetski algoritam kao računarski proces koji imitira evolucijski proces u prirodi i primjenjuje ga na apstraktne jedinke.

U samom početku potrebno je izvršiti inicijalizaciju. Prilikom incijalizacije generira se početna populacija jedinki. Početna populacija se obično generira slučajnim odabirom rješenja iz domene ali moguće je početnu populaciju generirati uniformo ili usaditi početno rješenje u početnu populaciju dobiveno nekom drugom metodom.

Svaki evolucijski program održava populaciju jedinki u nekoj određenoj generaciji. Svaka jedinka predstavlja potencijalno rješenje problema koji se obrađuje. Svaka jedinka je predstavljena jednakom podatkovnom strukturom (broj, niz itd.). Te jedinke se nazivaju kromosomi. Svakom rješenju se pridružuje određena mjera kvalitete koja se naziva dobrota, a funkcija koju ta dobrota određuje naziva se funkcija dobrote. Iz stare populacije se formira nova populacija, izdvajajući, po nekom postupku odabira, bolje jedinke iz skupa postojećih. Neki članovi nove populacije podvrgnuti su utjecajima genetskih operatora koji iz njih formiraju nove jedinke. Operatori se dijele na unarne, koji stvaraju novu jedinku mijenjajući manji dio genetskog materijala (mutacijska grupa) i operatore višeg reda, koji kreiraju nove jedinke kombinirajući osobine nekoliko jedinki (grupa križanja).

Cijeli postupak se zaustavlja kada se ispune uslovi zaustavljanja ili istekne određeno vrijeme, a najbolji član trenutne generacije predstavlja rješenje.

Postoji opasnost da se dobro rješenje dobiveno nakon puno iteracija izgubi ukoliko ga genetski operatori izmijene. Stoga se javlja potreba za mehanizmom zaštite najbolje jedinke od bilo kakve izmjene tokom evolucijskog procesa. Takav mehanizam se naziva elitizam. Genetski algoritam sa ugrađenim elitizmom, iz generaciju u generaciju, asimptotski teži ka globalnom optimumu, odnosno rješenju problema. Međutim, da bi u svakom koraku evolucije zaštitili najbolju jedinku od bilo kakvih izmjena, potrebno ju je u svakom koraku i pronaći. Pretraživanje ili sortiranje zahtijeva procesorsko vrijeme pa se genetski algoritam može znatno usporiti.

Genetski algoritam simulira prirodni evolucijski proces. Za evolucijski proces kao i za genetski algoritam se može ustanoviti sljedeće:

* postoji populacija jedinki
* neke jedinke su bolje
* bolje jedinke imaju veću vjerovatnoću preživljavanja
* osobine jedinki su zapisane u kromosomima
* djeca nasljeđuju osobine roditelja
* nad jedinkom može djelovati mutacija.

Funkcioniranje genetskog algoritma predstavit ćemo sljedećim koracima (slika 2):

1. Definiranje problem i to u obliku kromosoma , definiranje veličine populacije N, te vjerovatnosti za mutaciju i križanje
2. Definiranje funkcije dobrote pomoću koje će se moći izmjeriti koliko dobro populacija odgovara zadatom problemu, te odabrati kromosomi koji će sudjelovati u mutaciji i križanju
3. Generisanje početne populacije kromosoma
4. Određivanje dobrote svakog pojedinog kromosoma
5. Bira se prvi par kromosoma koji će se križati i to iz početne populacije
6. Kreita se novi par kromosoma koji su nastali primjenom genetičkih operatora mutacije i križanja
7. Novi par kromosoma kreira novu populaciju veličine N
8. Ponavljanje koraka 5 dok se ne kreira dovoljno velika populacija
9. Početni kromosomi se zamjenjuju novim
10. Ponavljanje koraka 4 sve dok se ne zadovolji kriteriji koji smo postavili.

Prednosti genetskog algoritma:

* moguća primjena na velik broj problema
* dostupnost programske podrške
* rješava sve probleme koji se mogu predstaviti kao optimizacijski.

Nedostaci genetskog algoritma:

* teško definiranju dobre funkcije dobrote
* ne može se postići 100% pouzdanost rješenja
* konvergencija znatno sporija od ostalih numeričkih metoda
* zahtjev za velikom procesorskom snagom zbog izvođenja velikog broja računskih operacija.

**Diagram

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Slika 2: Dijagram toka genetskog algoritma

**2.3. Umjetna neuronska mreža**

Umjetna neuronska mreža (engl. Artificial neural network, skr. ANN) predstavlja, iz perspektive simuliranih neurona, proces obrađivanja informacija koristeći nelinearnu metodu mapiranja mehanizma obrade, skladištenja i pretraživanja informacija mozga kombinirajući ih sa mehanizmom umjetne inteligencije. Neuronska mreža je na određeni način sasavljena od velikog broja pojedinačnih neurona. Jedan neuron predstavlja jedan od ulaznih podataka za izlaznu prenosnu funkciju koja je sastavljena od nelinearnih funkcija. Kombinacija velikog broja neurona je složena i nelinearna.

Područje umjetnih neuronskih mreža započelo je radom na perceptronima početkom šezdesetih godina prošlog vijeka, a od sredine osamdesetih naraslo je do vrlo važnog i produktivnog istraživačkog polja koje uključuje prilično raznolike teme kao što je proučavanje biološke vjerodostojnosti različite mrežne topologije i pravila učenja, izgradnja teorijskih opravdanja, kao i praktične implementacije hardvera i softvera i poboljšanje algoritama praktičnog učenja.

ANN u današnjim razmatranjima elektroenergetskog sistema ima široku upotrebu. Predstavlja jedan od savremenih alata koji je uveden kao funkcija zaštite elektroenergetskog sistema. ANN ima moć prepoznavanja uzoraka, klasifikacije, generalizacije te je također korisna za aplikacije elektroenergetskog sistema jer se može izvršavati sa ‘off-line’ podacima. Ima izvrsne osobine kao što su imunost na buku te otpornost na kvarove.

ANN oponaša koncepte ljudskih neurona da bi postiglo mašinsko učenje i prepoznavanje obrazaca koristeći težinske veze i funkcije aktivacije čvorova.

Proces učenja umjetne neuronske mreže je podijeljen u dvije faze:

1. obuka
2. provjera.

Ono za šta, između ostalog, možemo koristiti ANN jeste prepoznavanje lokacije kvara u prenosnom elektroenergetskom sistemu. Klase uzoraka kvara koriste se za osposobljavanje ANN da prepoznaje obrasce kvara i shodno tome, identificira kvar. ANN možemo koristiti za otkrivanje problema kvalitete električne energije u elektroenergetskom sistemu te postoji mogućnost njene primjene pri relejnoj zaštiti.

ANN se uglavnom koristi za detekciju željenih stanja. Također, procjena lokacije kvara koju izračunava može biti važna dodatna informacija za osoblje koje radi na održavanju i popravci sistema.

Kada modeliramo ANN, u osnovi bi trebali na umu imati tri komponente (slika 3.) i to:

1. Sinapse biološkog neurona su modelirane kao težine. Bitno je naglasiti da je sinapsa biološkog neurona zapravo ono što međusobno povezuje neuronsku mrežu i daje snagu povezanosti. Za umjetni neuron težina je broj koji predstavlja sinapsu. Negativna vrijednost težine odražava inhibicijsku vezu, odnosno dolazi do prekida veze, dok pozitivne vrijednosti označavaju ekscitacijske veze, odnosno dolazi do uspostavljanja veze.
2. Stvarna aktivnost neuronske čelije, svi se unosi sumiraju i prilagođavaju težinama. Ova aktivnost predstavlja formiranje linearne kombinacije ulaza.
3. Funkcija aktiviranja kontrolira amplitude izlaza. Prihvatljivi opseg izlaza je obično između 0 i 1 ili može biti -1 i 1.

![Diagram

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Slika 3: Model umjetnog neurona

Neuronska mreža sastoji se od više neurona koji su raspoređeni u više slojeva (slika 4). Postoje tri osnovne vrste slojeva: ulazni sloj, skriveni sloj i izlazni sloj. Ulazni sloj je prvi sloj mreže i on obrađuje ulazne podatke. Izlazni sloj je posljednji sloj mreže u kojem su izlazi neurona, odnosno predviđanja rješenja.

![Diagram

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEFtaW5hAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM4MgAAkpIAAgAAAAM4MgAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Slika 4: Primjer strukture neuronske mreže

Kroz veze u brojnim jednostavnim elementima i uzorcima za učenje, neprestanim prilagođavanjem težine konačno se dobivaju pravi rezultati i rješavaju složene jednadžbe i nelinearni problem koji su uzrokovani kvarovima.

Zbog velike mogučnosti paralelne obrade, sposobnosti prilagodljivog učenja, korištenja kapaciteta distribuiranog skladištenja podataka, robusnosti tolerancije greške te generalizacije u dijagnostici kvara, ANN ima važnu primjenu. Analiza i interpretacija modela neuronskih mreža aktivno je područje istraživanja ali još uvijek nema predloženog pristupa koji bi ujedno bio općenit i zadovoljavajući.

**2.4. Neizrazita logika**

Sistemi neizrazite logike (engl. Fuzzy logic systems) predstavljaju po definiciji neizrazite koncepte i matematičke modele za rukovanje praktičnim konceptima koji su po sami sebi neizraziti kao što su prekomjerne vrijednosti struja ili gubici snage čiji se uzrok nestanka ne poznaje. Fuzzy identifikacija nesigurnih događaja i pojava prikazuje se radi uspostavljanja matematičkog modela i ulaznih varijabli. Korištenjem fuzzy logike su riješeni i poboljšani problemi učinkovitosti otkrivanja kvarova u elektroenergetskom sistemu što nam ukazuje na samu važnost primjene fuzzy logike. Teorija fuzzy prepoznavanja se uglavnom koristi u štićenju glavne zaštite transformatora, zaštiti vodova i zaštiti općenito. Budući da neizraziti sistemi neće utvrditi problem, ne zahtijeva se tačnost te ne postoji zahtjev za strogim podudaranjem faktora, dolazi do toga da se sa približnom tačnošću do određene mjere povećava tolerancija kvarova sistema.

Sistemi neizrazite logike su široko korišteni posljednjih godina u različitim aspektima različitih područja razmatranja. Koriste se u analizi toka snage pri prenosu i distribuciji pod različitim uslovima opterečenja.

Njihova upotreba je važna za izgradnju principa zaštite transformatora uzimajući u obzir vanjske kvarove kao što su struje ekstremnih vrijednosti i zasićenja strujnog transformatora. Koriste se pri dizajniranju relejne zaštite.

Fuzzy logika ili fuzzy sistemi su logični sistemi za standardizaciju i formalizaciju približnog zaključivanja. Slično je ljudskom donošenju odluka sa sposobnošću stvaranja tačnih rješenja iz određenih ili čak približnih informacija i podataka. Neizrazita logika je način na koji ljudski mozak radi, a mi ovu tehnologiju možemo koristiti u mašinama kako bi mogle raditi poput ljudi.

Ono što je sa inženjerske strane bitno jeste činjenica da primjena neizrazite logike pruža veću općenitost i poboljšanu sposobnost modeliranja složenih problema po niskim ili umjerenim troškovima rješenja.

Neizrazita logika omogućava određeni nivo dvosmislenosti tokom analize. Budući da ova dvosmislenost može odrediti dostupne informacije i umanjiti složenost problema, neizrazita logika je korisna u mnogim primjenama.

Za sisteme napajanja neizrazita logika je pogodna ondje gdje dostupne informacije uključuju određeni nivo greške. Na primjer, problem može uključivati logičko zaključivanje ali se može osim simboličkih primijeniti i na numeričke ulaze i izlaze. Neizrazita logika pruža konverzije sa numeričkih na simbolučke ulaze,a isto vrijedi i za izlaze.

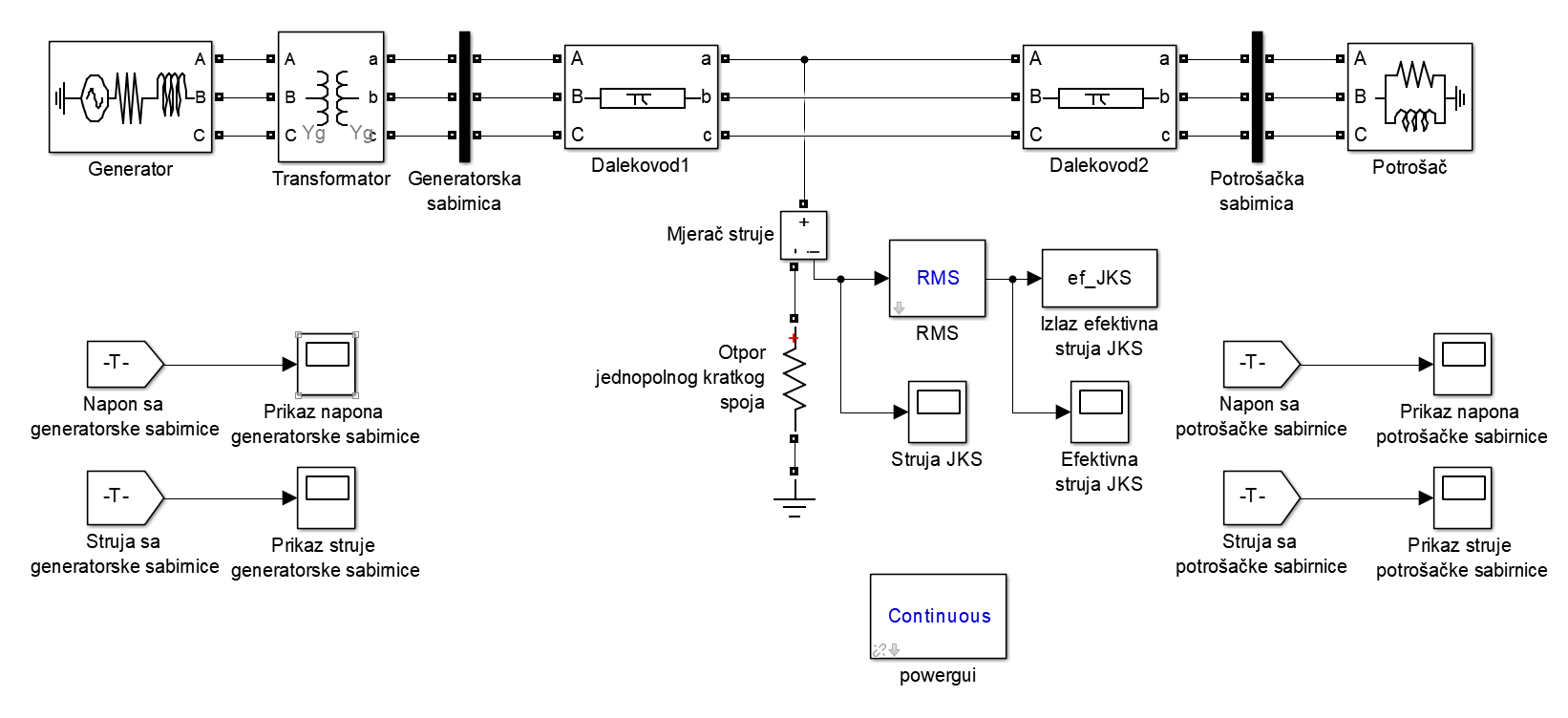
Fuzzy logiku možemo primijeniti u sljedećim aspektima:

* analiza i poboljšanje stabilnosti
* upravljanje
* dijagnoza kvara
* procjena sigurnosti
* predviđanje opterećenja
* planiranje reaktivne snage i njeno upravljanje
* procjena stanja.

**3 PRAKTIČNI DIO RADA**

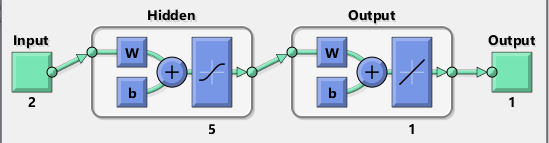
Za ekonomski razvoj modernog društva,neophodan je bio i ubrzan razvoj,proširenje i modernizacija elektroenergetskog sistema.U skladu sa prethodno navedenim osobinama,dominantno prednostima, vještačke intaligencija prestavlja jako važan faktor u mnogim segmentima razvoja elektroenegetskog sistema. Sa porastom snage koju zahtjevaju potrošači,samim tim i snage koja se prenosi od izvora električne energije preko prijenosih vodova su porasle što dovodi i do težih za otklanjanje i opasnijih po opremu i ljude (posebno na distributivnom nivou prenosa) havarijskih stanja. Kratki spojevi pretstavljaju jedan od najčećih uzroka problema u elektroenergetskom sistemu, uzrokuju mehanička i termička naprezanja opreme čiji je intenzitet raste sa vremenom trajanja kratkog spoja i proporcionalan je intenzitetu struje kratkog spoja. Samim tim dolazimo do zaljučka važnosti što bržeg reakcije pri kratkom spoju a ukoliko je moguće i analizom stanja sistema prognozirati njegovu lokaciju i pojavu i u što je moguće kraćem roku poslati upravljačke signale na prekidačke elemente.

U ovom rad prezentujemo jednostavan model za analizu jednopolnog kratkog spoja napravljen u Matlabu odnosno Simulniku,model je prikazan slici 5.



Slika 5: Model za analizu KS

Kao metoda vještačke intaligencije korištena je u prethodnom odjeljku definirana i opisana umjetna neuronska mreže(ANN). Pozadinski izgled umjetne neuronske mreže prikazan je na slici 6. Pri treniranju mreže a samim tim i analizi kao promjenljivi parametri su poslani otpor jednopolnog kratkog spoja i njegova udaljenost odnosno lokacija a kao povratni podatak dobijamo effektivnu vrijednost struje kratkog spoja.



Slika 6: Topologija umjetne neuronske mreže

Slojevi su sastavljeni od neurona, ulazni sloj se sastoji od 2 što je sinhornizovano sa brojem ulaznih podataka dok imamo jedna izlazi sloj što također odgovara jednom izlaznom podatku iz sistema.  
Broj neurona u skrivenom sloju jeste 5. Preciznost rezultata dobijenih putem umjetne neuronskem mreže raste sa nivoom utreniranosti,brojem primjera koji se šalju. Dati paramteri za analizu su proizvoljno odabrani, i njihova zamjena bi mogla dovesti isto tako do jako korsnih rezultata (npr. kao izlaz iz ANN se vraća lokacija kratkog spoja pri poznavanju njegovog intenziteta). Podaci za analizu su učitavani iz Excel file-a,a i dobijeni rezultati su upisivani u isti dokument.

Kao izlazne vrijednosti date su i vrijednosti relativne greške neuronske mreže koje su jako male iz čega zaključujemo da je mreža jako dobro utrenirana.