UNIT V

ADVANCED INTELLIGENT SYSTEMS AND FUTURE AI TECHNOLOGIES

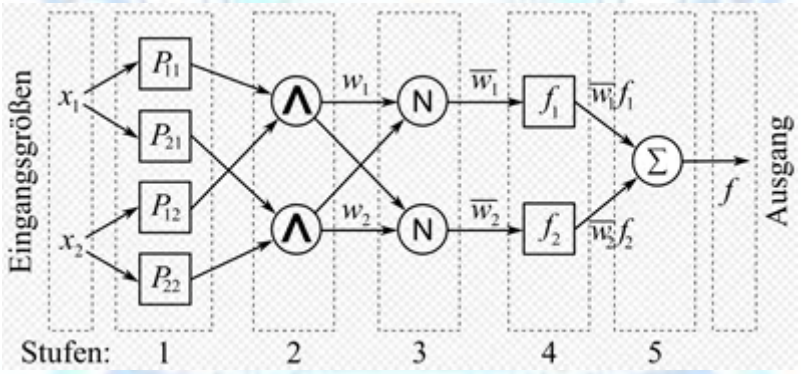
5.1 Neuro-Fuzzy Systems

Modern Techniques of Artificial Intelligence have revolutionized the world and the advancement aims at handling any computational and contemplative task automatically with more processing power than human brain. Neuro-fuzzy systems comprised of two very important techniques.

Neural Networks: It is defined as a set of algorithms that works hard in drawing a relationship of operational data set with the help of a process that mimic with the idea of human brain operation.

Fuzzy Systems: Systems based on fuzzy logic oriented towards information processing where the use of classical theory or binary is impossible to implement.

Fuzzy Logic: It is defined as the form of many valued logics, where the value of variable (truth value) is real and lies between 0 and 1.



NFS is system which uses the concept of learning with the help of algorithms available in the neural network theory. It is represented as a 3 layered feedforward neural network. These systems help us to understand the dynamic performances of peoples. They are capable of controlling machines, gives adequate thinking and also aids in managing the vulnerabilities in the systems. These systems can be programmed easily and rapidly, the outcomes of these systems provide knowledge that can't be revealed via statistical analysis.

Layer 1: it represents the input variables of the system.

Layer 2: It represents the fuzzy logic/techniques applied on the input variables for the desired output from the system.

Layer 3: It represents the output variable of the system.

Types of Neuro Fuzzy Systems:

Basically all the combinations of these fuzzy techniques with artificial networks can be called as NFS but on the basis of these combinations they are divided as follows:

1. Cooperative Neuro-Fuzzy Systems:

In Cooperative NFS the neural networks are only used in the initial phase and they are only used to determine the sub-blocks of the fuzzy system using training data, after this the neural networks are removed from the system and only fuzzy system is executed.

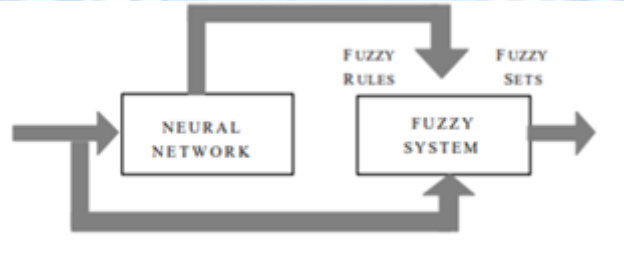


Fig: Cooperative NFS

The only disadvantage of the cooperative NFS is that their structure is not interpretable.

2. Concurrent Neuro-Fuzzy Systems:

It's basically not a NFS if compared in the strict sense as the neural networks works together with the fuzzy system. Meaning, the input enquired by the fuzzy system is pre-processed and then the neural networks process the output in the reverse way.

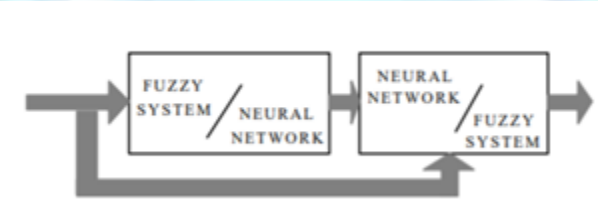


Fig: Concurrent NFS

3. Hybrid Neuro-Fuzzy Systems:

"*A Hybrid neuro-fuzzy systems is the system which uses a learning algorithm based on the gradients or is inspired by the neural networks theory*". They allow the comparison of the different models and to visualize their structural differences.

Neuro-Fuzzy Systems Architectures:

1. FALCON (Fuzzy Adaptive Learning Control Network) Architecture:

It is a five layered architecture as there are two linguistic nodes for each output, one is for the defining the patterns and other one is for the real output of the FALCON. Layer 1: It is responsible for the mapping of the input variables relatively to each membership functions. Layer2: It is responsible for defining the antecedents of the rules followed by consequents in Layer 3. It uses Hybrid learning algorithm composed of unsupervised learning for defining initial membership function.

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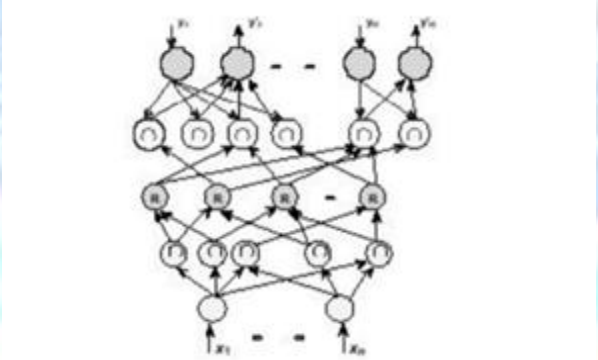


Fig: FALCON Architecture

2. GARIC (Generalized Approximate Reasoning Based Intelligence Control) Architecture:

GARIC architecture, the working of this type of architecture requires the use of 2 neural network, **ASN (Action Selection Network) and AEN (Action State Evaluation Network).** GARIC uses the mean of local mean of maximum method for calculating the output of the rules. Conclusion of the architecture should be transformed from fuzzy values for numerical value in the end. GARIC architecture, it includes **gradient descending** and **reinforcement learning** which enables the fine adjustments of its internal parameters.

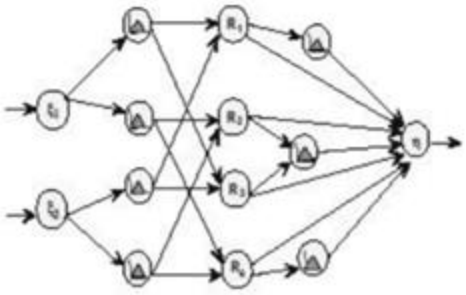


Fig: GARIC Architecture.

Advantages of NFS:

They are precise systems and do not require precise inputs as these systems are capable of accommodating several types of inputs including vague or imprecise data.

· If any sensors fail, then these systems can be reprogrammed according to the situation.

· These systems resemble human reasoning, so these systems are capable of solving complex problems and take decisions carefully.

· These systems have simple structure and their structures can be constructed easily and are flexible, their rules can be modified.

Disadvantages of NFS.

· These systems have no systematic approach because of the availability of many solutions and results in confusion.

· These systems require lot of verification and testing.

Neuro-Fuzzy Systems Applications:

1. NFS in Student Modelling

Applications of NFS are becoming more and more popular in the educational fields and research regarding the same many research have been conducted in the last decade. NFS have a wide variety of applications in education field. **Intelligent Tutoring System (ITS)** which provides a description for the student related information such as **his knowledge level and skills, preferences** have Student Modelling as its component. Students Modelling includes **student classification, monitoring student's actions, processing intelligent learning environments(ILE)** for the students.

2. **NFS in Medical System.**

Diagnosis of diseases at the early stages will decrease the death rate and in the last **2 decades' neuro fuzzy applications are getting huge attention** and many researches have been conducted**. NFS are used for various disease diagnosis like Breast cancer, brain disorder, thyroid disorder, leukaemia, heart disease** etc. It would not be wrong to say, NFS are used in almost all applications of health and medical systems.

3. NFS in Economic System

NFS systems are smart and can be applied anywhere in the world. Economic systems are the organizations which are important for the countries as they distribute, consumes, buy or sells services and goods. **NFS can be applied in the stock market, toll collection, energy consumption, price prediction and etc.**

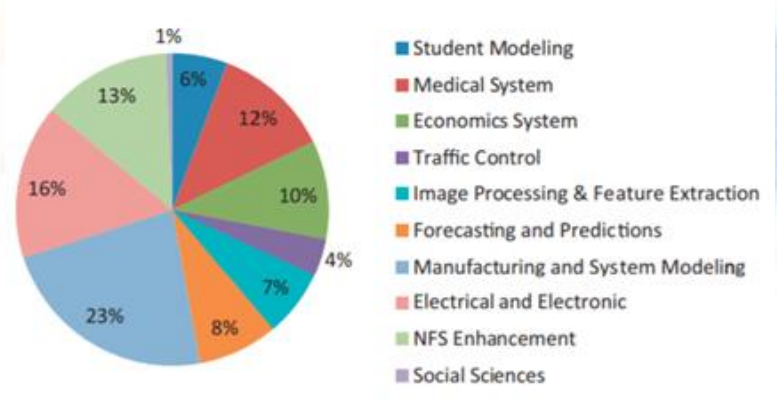


Fig: Impact of NFS on various categories

Analysis:

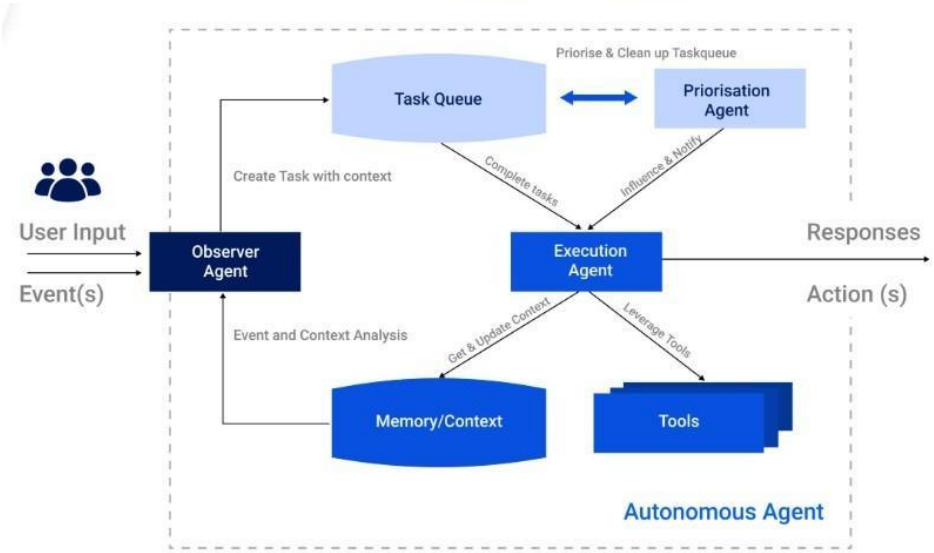
This pie chart proves that the NFS application covers all the sectors of industries, organizations, government parameters.

4. NFS in Industries:

They are also used in Industries for applications **in controlling water purification plants, pattern analysis for quality assurance, tackling sludge wastewater treatment**.

AI Agents and Autonomous Systems

Autonomous Agents are AI-powered programs that operate with a high degree of independence, that means unlike traditional bots which need human triggers and follow strict rules, autonomous agents are adaptive and capable of making decisions in dynamic environments. They operate by continuously observing their environment, reasoning through goals and context and then taking actions.



Key Capabilities

1. **Self-Learning and Adaptation**: Autonomous agents uses large language models (LLMs) and machine learning algorithms to process data in real time and improve continuously. By learning from previous interactions they refine their decisions and become more efficient over time hence enhancing their ability to execute tasks accurately and effectively.
2. **Autonomous Decision-Making**: These agents analyze data, predict potential outcomes and make informed decisions independently. Using historical patterns they optimize their choices without requiring human intervention.
3. **Scalability Across Domains**: Autonomous agents can operate across diverse industries and scale effortlessly to accommodate growing workloads. Their ability to optimize ensures consistent performance, even in rapidly evolving business environments.

4. **Collaborative Intelligence**: These agents are capable of collaboration with other AI systems and autonomous agents. In multi-agent ecosystems such coordination leads to faster execution and more intelligent, integrated solutions.
5. **Real-Time Responsiveness**: Autonomous agents dynamically adapt their actions and strategies based on new information or unforeseen challenges. Their ability to respond instantly ensures resilience and sustained productivity in dynamic work settings.

AI Agents vs Autonomous Agents

AI Agents and Autonomous Agents are quite similar and confusing so now we will see a quick difference between AI Agents and Autonomous Agents:

Feature	AI Agents	Autonomous Agents
Independence	Operate based on predefined rules and require human oversight.	Possess higher autonomy, learning and adapting to their environment.
Decision-Making	Follow programmed logic to execute tasks.	Analyze data, self-improve and refine decision-making over time.
Adaptability	Limited ability to adjust to new data or environments.	Continuously evolve and optimize behavior based on interactions.
Human Intervention	Require frequent input and supervision.	Can function with minimal or no human intervention.
Use Cases	Chatbots, recommendation engines and predictive analytics.	Autonomous robotics, automated trading and AI-driven cybersecurity.

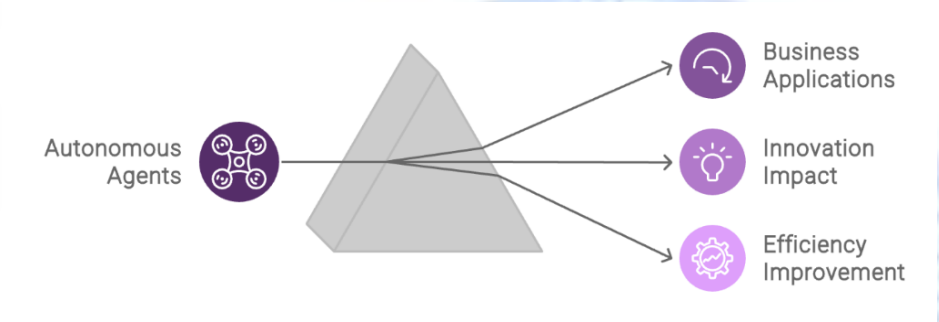
Real-World Applications

1. IT & Operations

In IT service management, agents can handle password resets, monitor uptime and even resolve incidents without human intervention. For example, if a server CPU spikes the agent can diagnose the issue or notify the right teams instantly.

2. HR & Employee Support

Autonomous agents streamline onboarding, handle leave requests and guide new employees through training materials. This reduces HR workload while improving employee experience.



Applications of Autonomous Agents

3. Finance & Accounting

Agents are being used to reconcile invoices, process expense reports, detect anomalies in financial transactions and automate audit trails. Their ability to handle large volumes of repetitive, rules-based work makes them ideal for back-office finance tasks.

4. Customer Support

Customer service agents powered by AI are now capable of handling complex interactions. They can manage returns, process refunds and hand off to human representatives when needed. They learn from each interaction hence improving performance over time.

5. Personal Productivity

On an individual level, autonomous agents manage calendars, summarize emails, create reminders and prioritize to-do lists. Tools like AI email assistants or scheduling bots are already improving how knowledge workers manage time and focus.