# Fuzzy Logic Main CW Idea

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## Possible Titles:

"Celestial Classification: A Fuzzy Logic Approach to Planetary Categorisation"

"FuzzyPlanets: Classifying Planetary Objects and Actions Using Fuzzy Logic"

"Beyond Crisp Boundaries: Fuzzy Logic-Based Classification of Celestial Phenomena"

"Cosmic Fuzziness: Exploring Planetary Classification with Fuzzy Logic"

"AstroFuzzy: An Intelligent System for Classifying Planetary Objects and Behaviours"

"Nebulous Classifications: Fuzzy Logic-Based Categorisation of Celestial Entities"

"Planetary Fuzzy: A Fuzzy Logic Framework for Planetary Object and Action Classification"

"Celestial Fuzz: Using Fuzzy Logic to Understand and Classify Planetary Phenomena"

"Stars, Planets, and Fuzzy Sets: A Fuzzy Logic Approach to Celestial Classification"

"Fuzzy Orbits: Classifying Planetary Objects and Movements with Fuzzy Logic"

## Classifying Planetary Objects:

Define linguistic variables representing different characteristics of planetary objects such as size, mass, distance from the sun, etc.

Create fuzzy membership functions for each linguistic variable, such as 'small,' 'medium,' and 'large' for size.

Design fuzzy rules that relate these linguistic variables to the classification of planetary objects (e.g., 'If the size is small and the mass is medium, then classify as a rocky planet').

Implement the fuzzy inference system (FIS) using MATLAB's Fuzzy Logic Toolbox, where you input the characteristics of a planetary object and obtain the classification as output.

## Categorising Planetary Actions:

Define linguistic variables representing different attributes of planetary actions, such as speed, direction, magnitude, etc.

Develop fuzzy membership functions for each linguistic variable, such as 'slow,' 'moderate,' and 'fast' for speed.

Establish fuzzy rules that correlate these linguistic variables to the categorization of planetary actions (e.g., 'If the speed is fast and the direction is towards the sun, then classify as a comet approaching the sun').

Implement the fuzzy inference system (FIS) using MATLAB's Fuzzy Logic Toolbox to classify planetary actions based on their attributes.

## Combining Object and Action Classification:

Integrate the fuzzy inference systems for planetary objects and actions to create a comprehensive classification system.

Define additional linguistic variables and fuzzy rules to capture the relationship between planetary objects and their associated actions (e.g., 'If the planetary object is classified as a comet and the action is approaching the sun, then classify as a sungrazing comet').

Implement the combined fuzzy inference system in MATLAB to classify both planetary objects and their associated actions simultaneously.

## Linguistic Variables for Actions

These actions encompass various orbit-related, surface-related, and dynamic behaviours observed in space, providing a comprehensive perspective on the interactions and movements of planetary objects.

|  |  |  |
| --- | --- | --- |
| Orbiting the Sun: Far, Moderate, Close | Approaching the Sun: Far, Moderate, Close | Interstellar Travel: Low, Moderate, High |
| Orbiting a Planet: Far, Moderate, Close | Volcanic Activity: Low, Moderate, High | Solar Flare Activity: Low, Moderate, High |
| Close Encounter with a Celestial Body: Weak, Moderate, Strong | Atmospheric Entry: Weak, Moderate, Strong | Impact Event: Low, Moderate, High |

## Linguistic Variables (Attributes):

|  |  |
| --- | --- |
| Size: Small, Medium, Large | Rotation Speed: Slow, Moderate, Fast |
| Mass: Light, Medium, Heavy | Surface Features: Cratered, Smooth, Mountainous |
| Distance from the Sun: Close, Moderate, Far | Orbital Period: Short, Moderate, Long |
| Composition: Rocky, Gaseous, Ice | Axial Tilt: Low, Moderate, High |
| Surface Temperature: Cold, Moderate, Hot | Magnetic Field Strength: Weak, Moderate, Strong |
| Atmospheric Pressure: Low, Moderate, High | Eccentricity of Orbit: Circular, Elliptical |
| Albedo (Reflectivity): Low, Moderate, High | Atmospheric Composition: Thin, Moderate, Dense |
| Tidal Forces: Weak, Moderate, Strong | Surface Gravity: Low, Moderate, High |
| Ring System Presence: None, Partial, Complete | Magnetosphere Strength: Weak, Moderate, Strong |
| Geological Activity: Inactive, Moderate, Active | Orbital Inclination: Low, Moderate, High |

## Categorising Membership Functions (Discreet or Continuous):

### Size:

Measured by: Physical dimensions (e.g., diameter, volume)

Discrete or Continuous: Typically, continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Rotation Speed:

Measured by: Angular velocity (e.g., rotations per minute)

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Mass:

Measured by: Kilograms or other units of mass

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Surface Features:

Measured by: Qualitative assessment of surface characteristics (e.g., presence of craters, smoothness)

Discrete or Continuous: Discrete

Best Membership Function: Triangular functions are appropriate for discrete features such as cratered, smooth, and mountainous.

### Distance from the Sun:

Measured by: Astronomical units (AU) or other units of distance

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Orbital Period:

Measured by: Time taken to complete one orbit (e.g., days, years)

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Composition:

Measured by: Chemical composition (e.g., presence of rock, gas, ice)

Discrete or Continuous: Discrete

Best Membership Function: Triangular functions are suitable for discrete compositions like rocky, gaseous, and icy.

### Axial Tilt:

Measured by: Angle of tilt of the planetary axis relative to its orbit

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Surface Temperature:

Measured by: Temperature in degrees Celsius or Kelvin

Discrete or Continuous: Continuous

Best Membership Function: Gaussian functions are suitable for representing continuous temperature ranges such as cold, moderate, and hot.

### Magnetic Field Strength:

Measured by: Magnetic flux density (e.g., teslas)

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Atmospheric Pressure:

Measured by: Pressure in pascals (Pa) or other units

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Eccentricity of Orbit:

Measured by: Dimensionless quantity representing the deviation of an orbit from circularity

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Albedo (Reflectivity):

Measured by: Dimensionless quantity representing the reflectivity of a surface

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Atmospheric Composition:

Measured by: Composition of gases in the atmosphere (e.g., nitrogen, oxygen, carbon dioxide)

Discrete or Continuous: Discrete

Best Membership Function: Triangular functions are appropriate for discrete compositions like thin, moderate, and dense.

### Tidal Forces:

Measured by: Gravitational forces exerted by nearby bodies (e.g., moons, other planets)

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Surface Gravity:

Measured by: Acceleration due to gravity at the surface

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Ring System Presence:

Measured by: Presence or absence of rings around the planet

Discrete or Continuous: Discrete

Best Membership Function: Triangular functions are suitable for discrete categories like none, partial, and complete.

### Magnetosphere Strength:

Measured by: Strength of the planetary magnetic field

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Geological Activity:

Measured by: Presence and intensity of geological processes (e.g., volcanism, tectonics)

Discrete or Continuous: Discrete

Best Membership Function: Triangular functions are suitable for discrete categories like inactive, moderate, and active.

### Orbital Inclination:

Measured by: Angle between the orbital plane and a reference plane

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature.

### Orbiting the Sun:

Linguistic terms: Far, Moderate, Close

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature of the distance from the sun.

### Approaching the Sun:

Linguistic terms: Far, Moderate, Close

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature of the distance from the sun.

### Orbiting a Planet:

Linguistic terms: Far, Moderate, Close

Discrete or Continuous: Continuous

Best Membership Function: Gaussian membership functions are more appropriate due to the smooth and continuous nature of the distance from the planet.

### Volcanic Activity:

Linguistic terms: Low, Moderate, High

Discrete or Continuous: Discrete

Best Membership Function: Triangular membership functions are suitable for discrete categories like low, moderate, and high volcanic activity.

### Impact Event:

Linguistic terms: Low, Moderate, High

Discrete or Continuous: Discrete

Best Membership Function: Triangular membership functions are suitable for discrete categories like low, moderate, and high impact events.

### Atmospheric Entry:

Linguistic terms: Weak, Moderate, Strong

Discrete or Continuous: Discrete

Best Membership Function: Triangular membership functions are suitable for discrete categories like weak, moderate, and strong atmospheric entry.

### Solar Flare Activity:

Linguistic terms: Low, Moderate, High

Discrete or Continuous: Discrete

Best Membership Function: Triangular membership functions are suitable for discrete categories like low, moderate, and high solar flare activity.

### Interstellar Travel:

Linguistic terms: Low, Moderate, High

Discrete or Continuous: Discrete

Best Membership Function: Triangular membership functions are suitable for discrete categories like low, moderate, and high interstellar travel.

### Close Encounter with a Celestial Body:

Linguistic terms: Weak, Moderate, Strong

Discrete or Continuous: Discrete

Best Membership Function: Triangular membership functions are suitable for discrete categories like weak, moderate, and strong encounters.

## Possible Membership Functions for UFO Sightings:

### Shape:

Linguistic terms: Saucer-shaped, Triangular-shaped, Cigar-shaped, Spherical-shaped, Irregular-shaped

Discrete or Continuous: Discrete (as the shape is typically described qualitatively)

Membership Functions: Triangular or trapezoidal membership functions can be used for discrete categories.

### Motion:

Linguistic terms: Manoeuvrable, High-speed, Stationary, Sudden movement, Linear motion

Discrete or Continuous: Discrete (as the motion patterns are described qualitatively)

Membership Functions: Triangular or trapezoidal membership functions can be used for discrete categories.

### Lighting:

Linguistic terms: Light-emitting, Dark, Glowing, Multi-coloured

Discrete or Continuous: Discrete (as the lighting characteristics are described qualitatively)

Membership Functions: Triangular or trapezoidal membership functions can be used for discrete categories.

### Size and Distance:

Linguistic terms: Close-range, Medium-range, Long-range

Discrete or Continuous: Discrete (as the size and distance are described qualitatively)

Membership Functions: Triangular or trapezoidal membership functions can be used for discrete categories.

### Witness Credibility:

Linguistic terms: Credible, Unverified

Discrete or Continuous: Discrete (as witness credibility is assessed qualitatively)

Membership Functions: Triangular or trapezoidal membership functions can be used for discrete categories.

## Possible Rules

### Rulebase (Planets):

#### Mercury:

If the planetary object has a heavily cratered surface, no significant atmosphere, low mass, and is closest to the sun, then classify as Mercury.

#### Venus:

If the planetary object has a dense atmosphere composed mainly of carbon dioxide, extensive dust storms, high surface temperature, and is second closest to the sun, then classify as Venus.

#### Earth:

If the planetary object has a moderate axial tilt, liquid water on its surface, a diverse ecosystem, and is the only known planet with life, then classify as Earth.

#### Mars:

If the planetary object has a thin atmosphere composed mainly of nitrogen, polar ice caps, extensive volcanic plains, and is often referred to as the "Red Planet," then classify as Mars.

#### Jupiter:

If the planetary object has a predominantly gaseous composition, extensive ring system presence, strong magnetic field strength, and is the largest planet in the solar system, then classify as Jupiter.

#### Saturn:

If the planetary object has a large, visible ring system, low surface temperature, extensive moons, and exhibits distinctive cloud bands, then classify as Saturn.

#### Uranus:

If the planetary object has a predominantly icy composition, low surface temperature, low surface gravity, and is tilted on its side relative to its orbit, then classify as Uranus.

#### Neptune:

If the planetary object has a thick atmosphere composed mainly of hydrogen and helium, high surface temperature, exhibits rapid cloud movements, and is the farthest known planet from the sun, then classify as Neptune.

#### Pluto:

If the planetary object has a highly eccentric orbit, exhibits rapid rotation, and is located in the Kuiper Belt, then classify as Pluto.

##### To classify as planet-like:

If the planetary object has a rocky composition, moderate axial tilt, moderate surface temperature, and moderate surface gravity, then classify as Earth-like planet.

If the planetary object has a predominantly gaseous composition, extensive ring system presence, strong magnetic field strength, and high surface temperature, then classify as a gas giant like Jupiter.

If the planetary object has a predominantly icy composition, low surface temperature, low surface gravity, and low albedo, then classify as an ice giant like Uranus.

If the planetary object has a heavily cratered surface, no significant atmosphere, low mass, and is located in the asteroid belt, then classify as a dwarf planet like Ceres.

If the planetary object has a highly eccentric orbit, exhibits rapid rotation, and has a high albedo, then classify as a Kuiper Belt object like Pluto.

If the planetary object has a dense atmosphere composed mainly of carbon dioxide, extensive dust storms, and a high surface temperature, then classify as a terrestrial planet like Venus.

If the planetary object has a large, visible ring system, low surface temperature, and extensive moons, then classify as a gas giant like Saturn.

If the planetary object has a thin atmosphere composed mainly of nitrogen and has polar ice caps, then classify as a terrestrial planet like Mars.

If the planetary object has a low density, extensive volcanic plains, and no moons, then classify as a terrestrial planet like Mercury.

If the planetary object has a thick atmosphere composed mainly of hydrogen and helium, high surface temperature, and exhibits rapid cloud movements, then classify as a gas giant like Neptune.

### Rulebase (Actions):

If the planetary object is classified as a comet and the action is approaching the sun, then classify as a sungrazing comet.

If the planetary object is classified as a comet and the action is leaving the solar system, then classify as an interstellar comet.

If the planetary object is classified as a comet and the action is exhibiting a tail, then classify as a comet with an active coma.

If the planetary object is classified as a planet and the action is orbiting the sun, then classify as a planet in stable orbit.

If the planetary object is classified as a planet and the action is experiencing a magnetic storm, then classify as a magnetically active planet.

If the planetary object is classified as a moon and the action is orbiting a planet, then classify as a moon in stable orbit.

If the planetary object is classified as a moon and the action is approaching the end of its life cycle, then classify as a tidally disrupted moon.

If the planetary object is classified as a moon and the action is experiencing volcanic activity, then classify as a geologically active moon.

If the planetary object is classified as an asteroid and the action is close encounter with a celestial body, then classify as a potentially hazardous asteroid.

If the planetary object is classified as an asteroid and the action is entering a stable orbit around a planet, then classify as a captured asteroid.

If the planetary object is classified as a spacecraft and the action is interstellar travel, then classify as an interstellar probe.

If the planetary object is classified as a spacecraft and the action is entering the atmosphere, then classify as a space capsule re-entering Earth's atmosphere.

If the planetary object is classified as a spacecraft and the action is orbiting a celestial body, then classify as a space probe in orbit.

If the planetary object is classified as a meteoroid and the action is atmospheric entry, then classify as a meteor.

If the planetary object is classified as a planet and the action is orbiting a planet, then classify as a natural satellite.

If the planetary object is classified as a planet and the action is close encounter with a celestial body, then classify as a potential impactor.

If the planetary object is classified as a planet and the action is approaching the sun, then classify as a terrestrial planet.

If the planetary object is classified as a planet and the action is leaving the solar system, then classify as a rogue planet.

If the planetary object is classified as a planet and the action is exhibiting a tail, then classify as a gas giant with a comet-like tail.

If the planetary object is classified as a planet and the action is experiencing a magnetic storm, then classify as a gas giant with magnetic disturbances.

If the planetary object is classified as a planet and the action is experiencing volcanic activity, then classify as a terrestrial planet with active volcanism.

If the planetary object is classified as a planet and the action is experiencing seismic activity, then classify as a terrestrial planet with tectonic activity.

If the planetary object is classified as a moon and the action is exhibiting cryovolcanism, then classify as an icy moon with cryovolcanic activity.

If the planetary object is classified as a moon and the action is undergoing tidal heating, then classify as an icy moon with internal heating.

If the planetary object is classified as an asteroid and the action is disintegrating due to solar radiation, then classify as a rubble-pile asteroid.

If the planetary object is classified as an asteroid and the action is undergoing Yarkovsky drift, then classify as a potentially hazardous asteroid with orbital perturbations.

If the planetary object is classified as a comet and the action is exhibiting outgassing, then classify as a comet with sublimation-driven activity.

If the planetary object is classified as a comet and the action is undergoing fragmentation, then classify as a comet with nucleus breakup.

If the planetary object is classified as a spacecraft and the action is docking with another spacecraft, then classify as a spacecraft engaged in space rendezvous.

If the planetary object is classified as a spacecraft and the action is performing a gravity assist manoeuvre, then classify as a spacecraft utilizing gravitational slingshot.

### Rulebase (UFO’s):

#### Shape:

If the observed object has a saucer-like shape, then classify as a saucer-shaped UFO.

If the observed object has a triangular shape, then classify as a triangular-shaped UFO.

If the observed object has a cigar-like shape, then classify as a cigar-shaped UFO.

If the observed object has a spherical shape, then classify as a spherical-shaped UFO.

If the observed object has an irregular or amorphous shape, then classify as an irregular-shaped UFO.

If the observed object exhibits erratic or zigzag motion patterns, then classify as a manoeuvrable UFO.

If the observed object moves at extremely high speeds, then classify as a high-speed UFO.

If the observed object hovers or remains stationary for an extended period, then classify as a stationary UFO.

If the observed object abruptly changes direction or accelerates rapidly, then classify as a sudden movement UFO.

If the observed object follows a predictable or straight-line trajectory, then classify as a linear motion UFO.

#### Lighting:

If the observed object emits bright, flashing, or pulsating lights, then classify as a light-emitting UFO.

If the observed object emits no visible lights but is discernible through other means (e.g., silhouette against the sky), then classify as a dark UFO.

If the observed object emits a constant or steady glow, then classify as a glowing UFO.

If the observed object changes colours or exhibits multi-coloured lights, then classify as a multi-coloured UFO.

#### Size and Distance:

If the observed object appears to be relatively small and nearby (e.g., within the Earth's atmosphere), then classify as a close-range UFO.

If the observed object appears to be large and distant (e.g., in space or high altitude), then classify as a long-range UFO.

If the observed object appears to be of intermediate size and distance, then classify as a medium-range UFO.

#### Witness Credibility:

If the observation is made by multiple credible witnesses (e.g., pilots, military personnel, astronomers), then classify as a credible UFO.

If the observation is made by a single witness or lacks corroborating evidence, then classify as an unverified UFO.

## Visualising Classification Results:

Use MATLAB's plotting capabilities to visualise the fuzzy membership functions, input-output relationships, and classification results.

Generate plots showing the classification of different planetary objects/actions based on varying input parameters.

Utilise MATLAB's GUI-building tools to create interactive interfaces for exploring the classification results visually.

## Pseudocode:

1. Define linguistic variables

A screenshot of a computer program

Description automatically generated

1. Create Fuzzy membership functions

A computer screen shot of a program

Description automatically generated

1. Define fuzzy rules

A black screen with white text

Description automatically generated

1. Implementation

A computer screen shot of white text

Description automatically generated