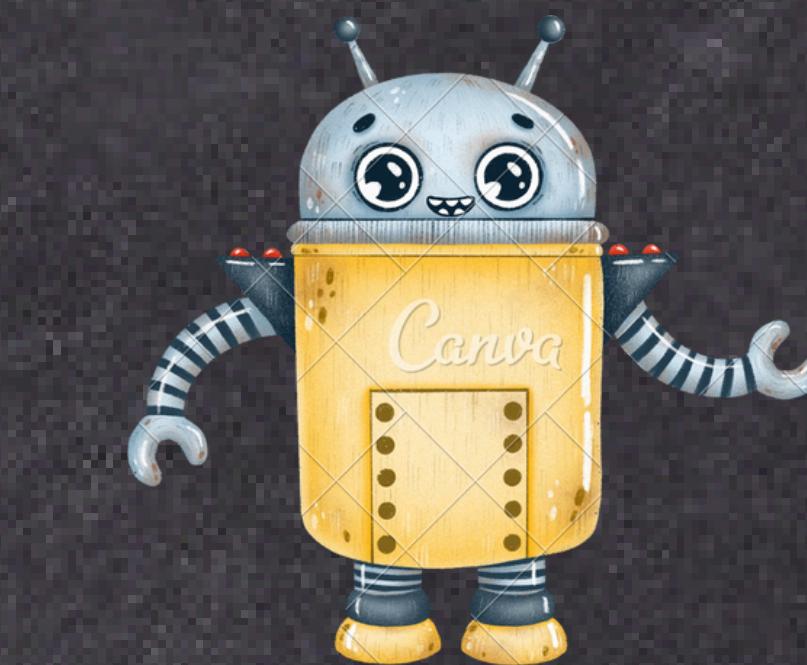


INTELLIGENT MOBILE ROBOT NAVIGATION USING COMPUTATIONAL INTELLIGENCE

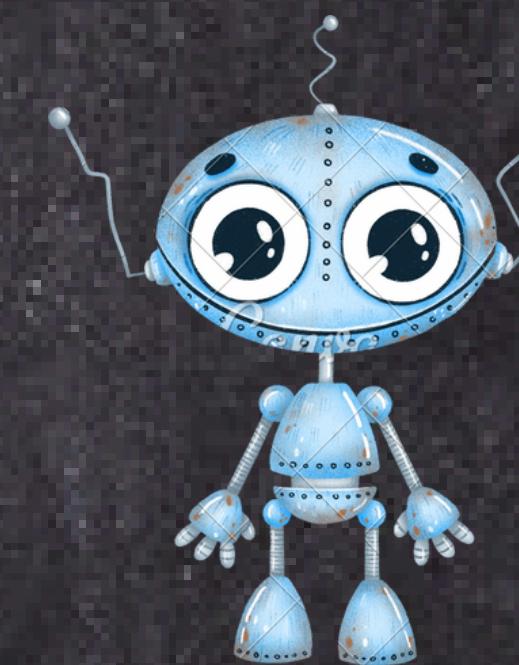
MCTA 3371 COMPUTATIONAL INTELLIGENCE



AHMAD NIZAR BIN AMZAH
2312111



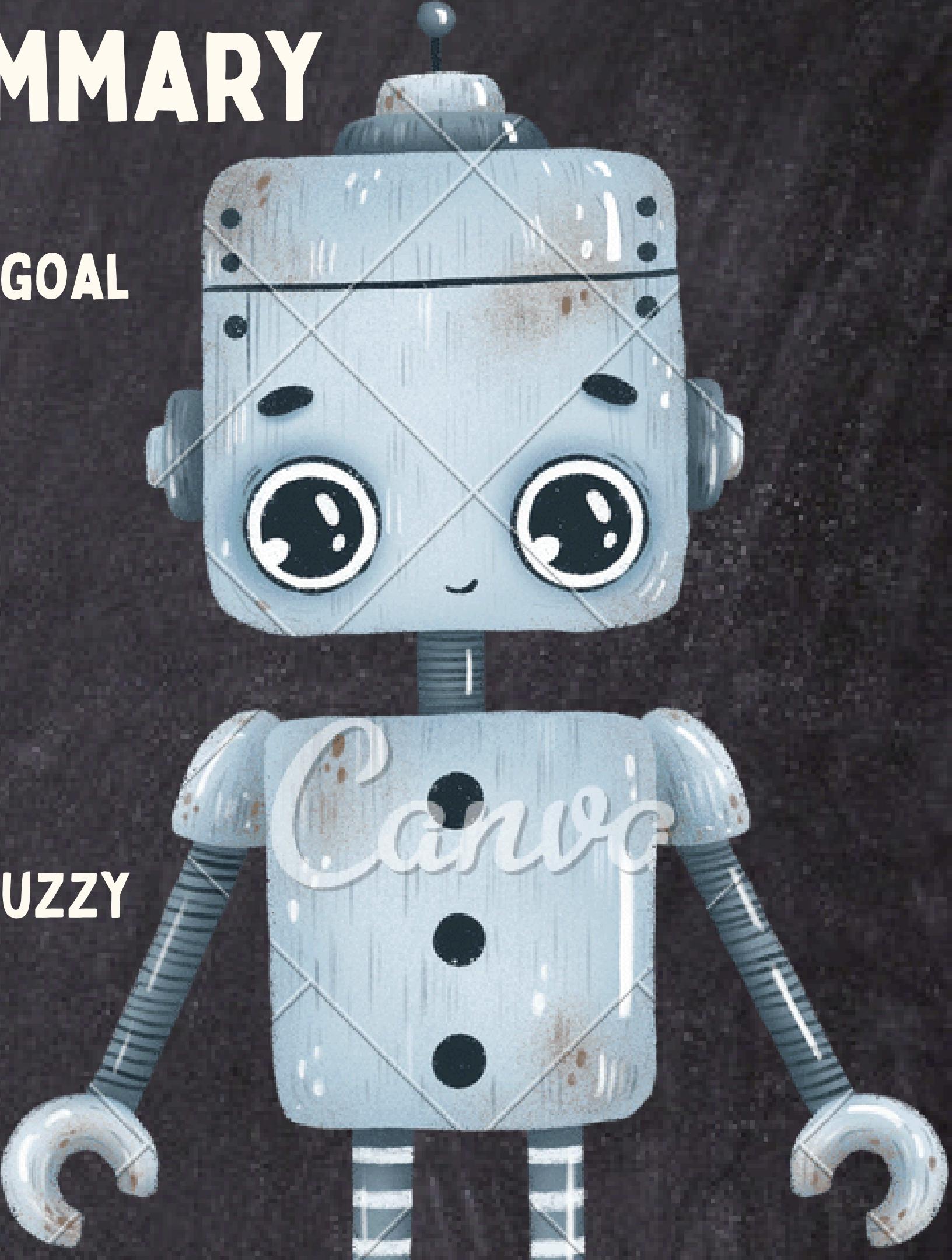
TAN YONG JIA
2319155



MUHAMMAD IRSYAD HAZIM BIN ROZAINI
2310303

PROJECT SUMMARY

- MOBILE ROBOT NAVIGATES FROM START TO GOAL WHILE AVOIDING OBSTACLES
- OPERATES IN UNCERTAIN ENVIRONMENTS
- USES FUZZY LOGIC FOR DECISION-MAKING
- GENETIC ALGORITHM OPTIMIZES FUZZY PARAMETERS AUTOMATICALLY

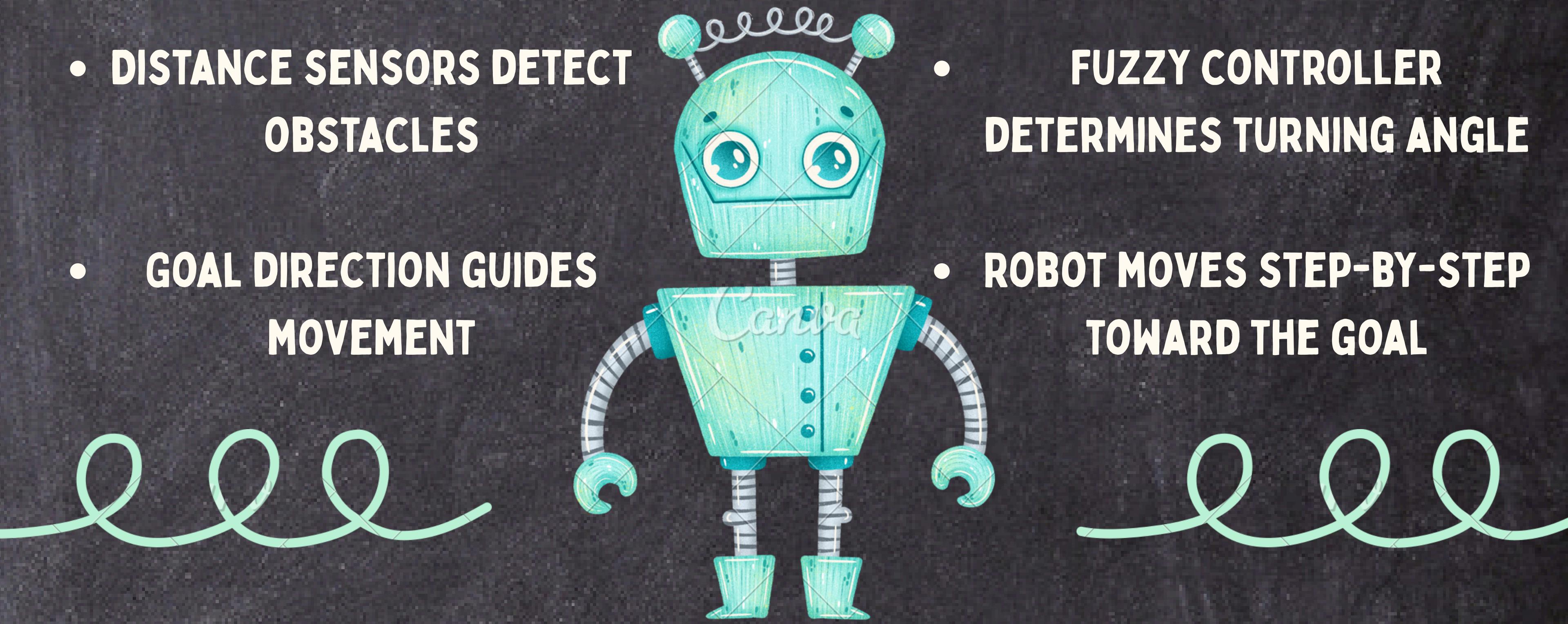


METHODOLOGY

ENVIRONMENT → SENSORS → FUZZY CONTROLLER → ROBOT MOTION

- DISTANCE SENSORS DETECT OBSTACLES
- GOAL DIRECTION GUIDES MOVEMENT

- FUZZY CONTROLLER DETERMINES TURNING ANGLE
- ROBOT MOVES STEP-BY-STEP TOWARD THE GOAL



FUZZY RULES USED

1. IF FRONT DISTANCE IS NEAR → THEN TURN HARD LEFT
2. IF FRONT IS NEAR AND LEFT IS NEAR → THEN TURN HARD RIGHT
3. IF LEFT IS NEAR AND FRONT IS FAR → THEN TURN HARD RIGHT
4. IF RIGHT IS NEAR AND FRONT IS FAR → THEN TURN HARD LEFT
5. IF FRONT IS FAR AND GOAL IS LEFT → THEN TURN LEFT
6. IF FRONT IS FAR AND GOAL IS RIGHT → THEN TURN RIGHT
7. IF FRONT IS FAR AND GOAL IS AHEAD → THEN GO STRAIGHT



FUZZY INPUT & OUTPUT

4 FUZZY INPUTS

- $D_L \rightarrow$ LEFT DISTANCE
- $D_F \rightarrow$ FRONT DISTANCE
- $D_R \rightarrow$ RIGHT DISTANCE
- $GOAL \rightarrow$ GOAL DIRECTION



1 FUZZY OUTPUT

STEERING ANGLE:
HARD LEFT
LEFT
STRAIGHT
RIGHT
HARD RIGHT

HYBRID INTELLIGENCE APPROACH

GA-OPTIMIZED FUZZY CONTROLLER

- FUZZY LOGIC:
 - HANDLES UNCERTAINTY
 - CONTROLS ROBOT STEERING
- GENETIC ALGORITHM:
 - OPTIMIZES FUZZY PARAMETERS
 - IMPROVES PERFORMANCE ACROSS MAPS

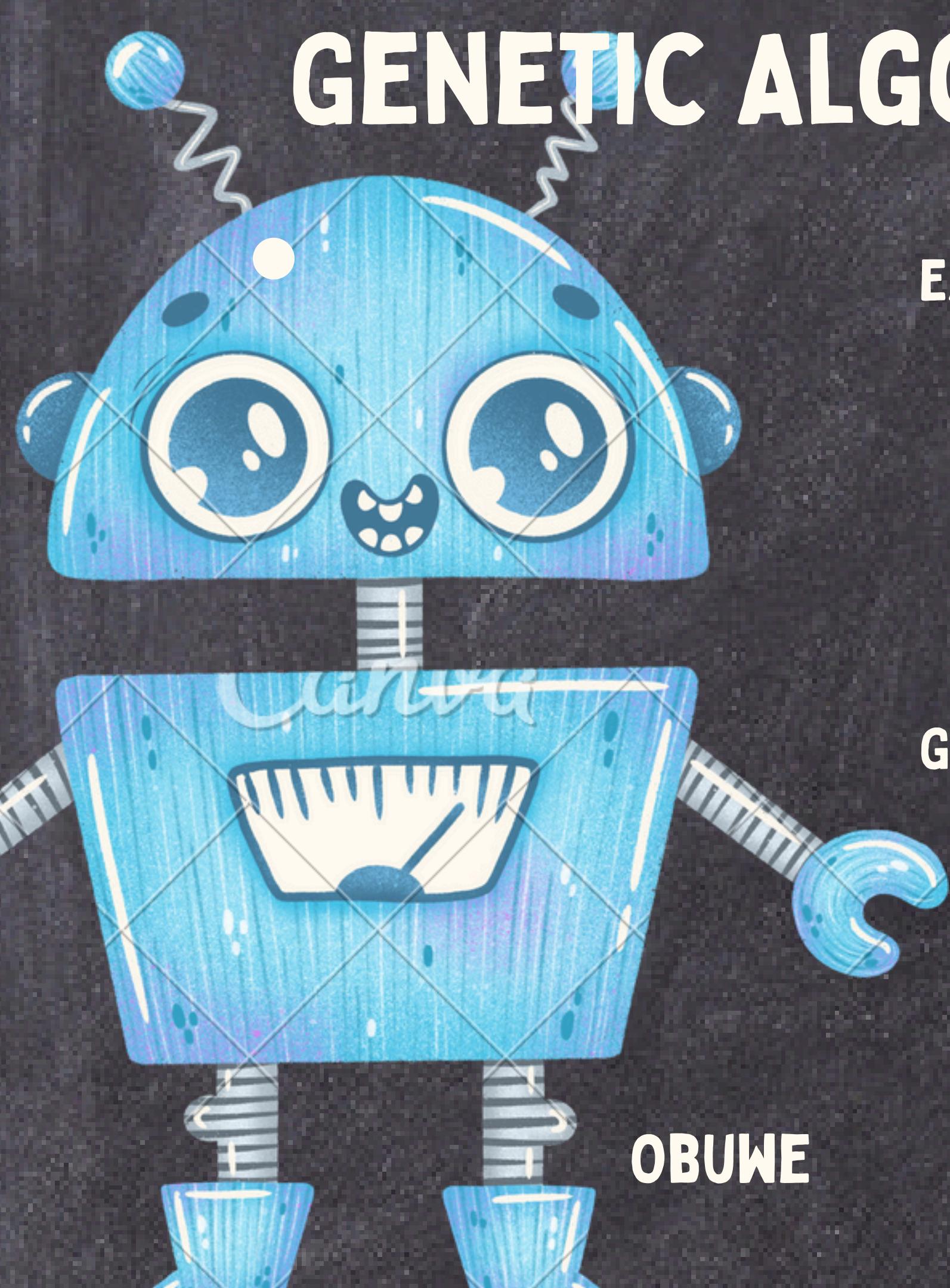
FITNESS CONSIDERS:

- GOAL REACHING
- COLLISIONS
- PATH EFFICIENCY
- TIME STEPS

Generation Fitness:

#1:	9691
#2:	9643
#3:	9641
#4:	9640
#5:	9622
#6:	9617
#7:	9614
#8:	9591
#9:	9567
#10:	9559
...	(10 more)

GENETIC ALGORITHM OPTIMIZATION



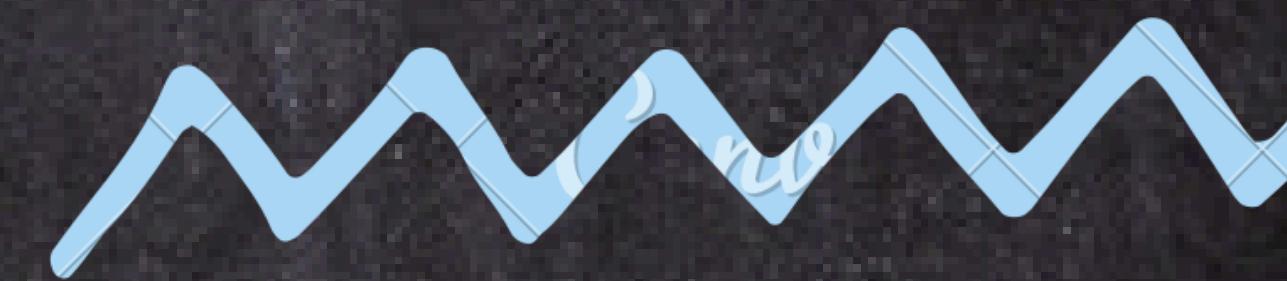
EACH GENOME REPRESENTS FUZZY CONTROL PARAMETERS:

- SENSITIVITY
- TURN POWER
- SPEED
- GOAL INFLUENCE

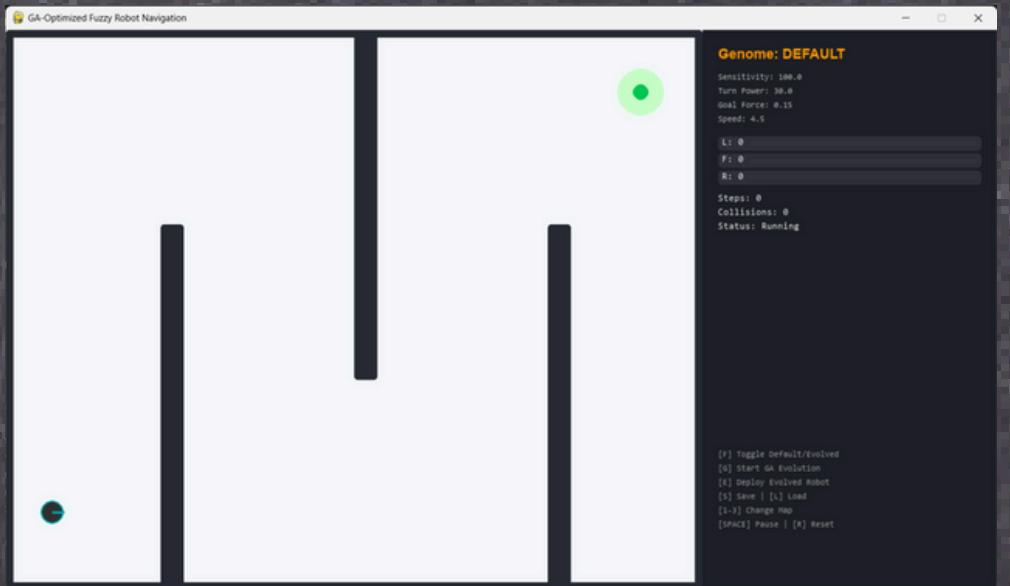
Sensitivity: 141.0
Turn Power: 40.0
Goal Force: 0.08
Speed: 6.0

GA OPERATIONS:

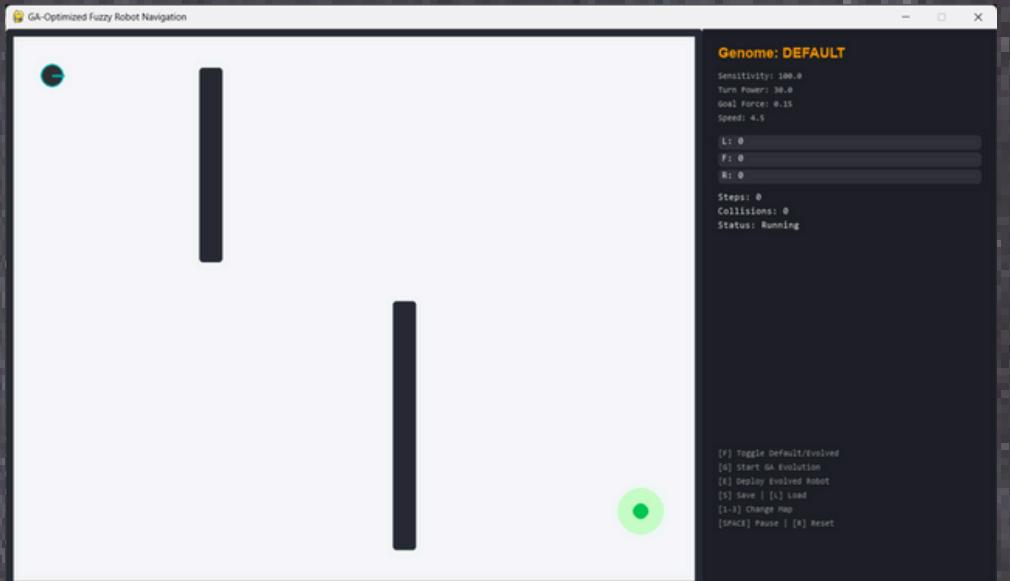
- SELECTION
- CROSSOVER
- MUTATION



SIMULATION ENVIRONMENT

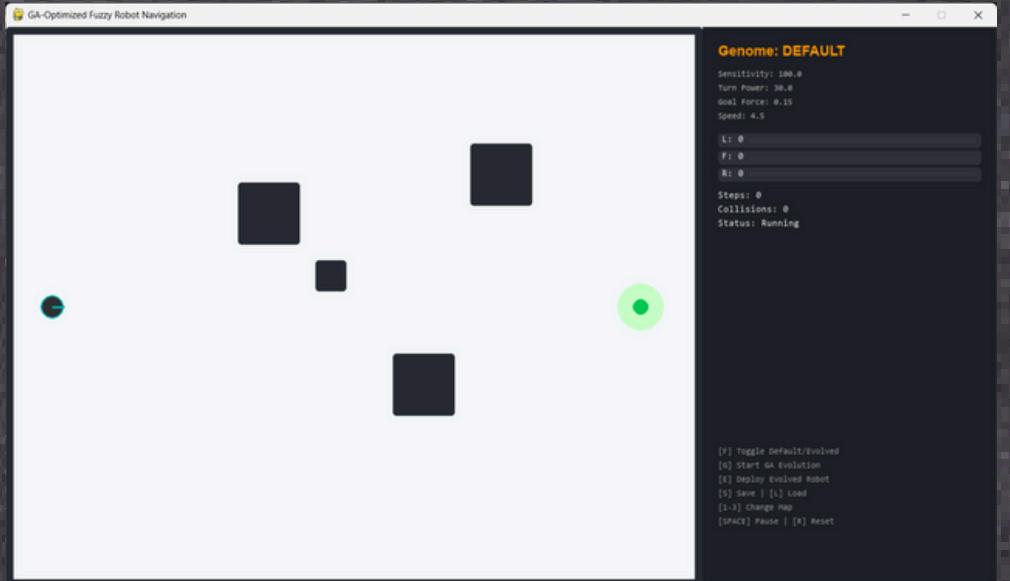


- 2D SIMULATION DEVELOPED USING PYTHON (PYGAME)
- ROBOT EQUIPPED WITH MULTIPLE DISTANCE SENSORS



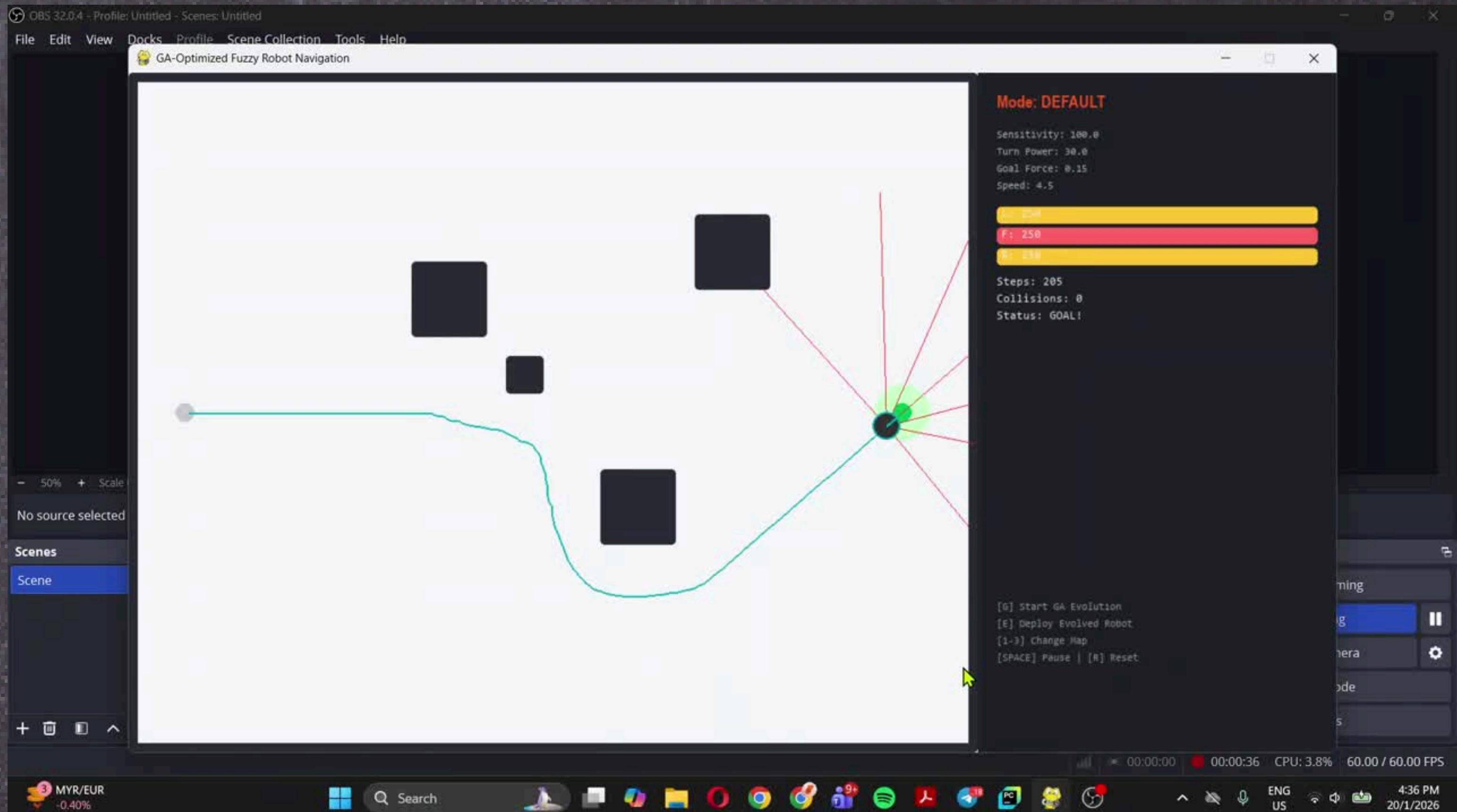
DIFFERENT MAPS TESTED:

- SIMPLE
- COMPLEX



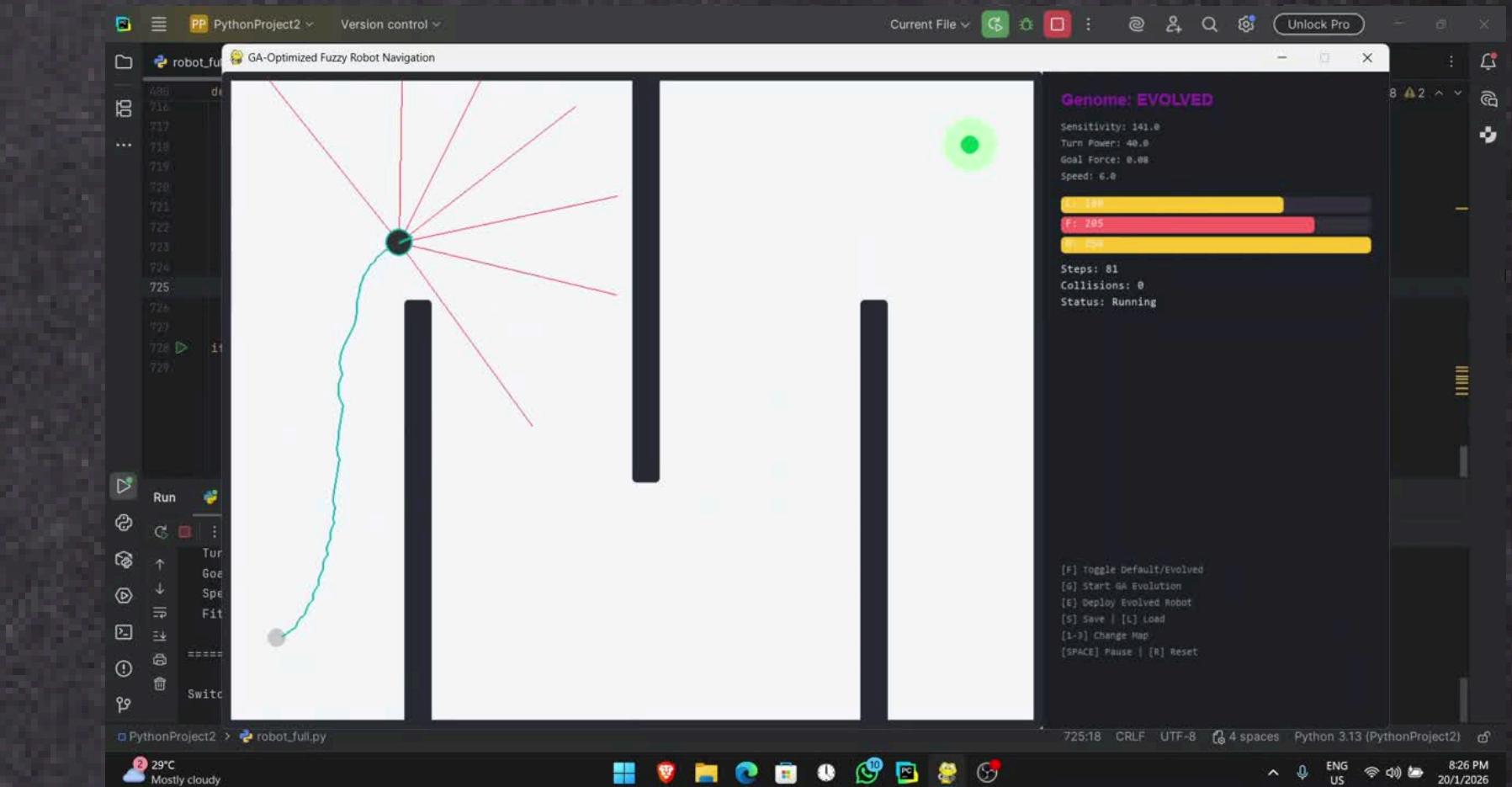
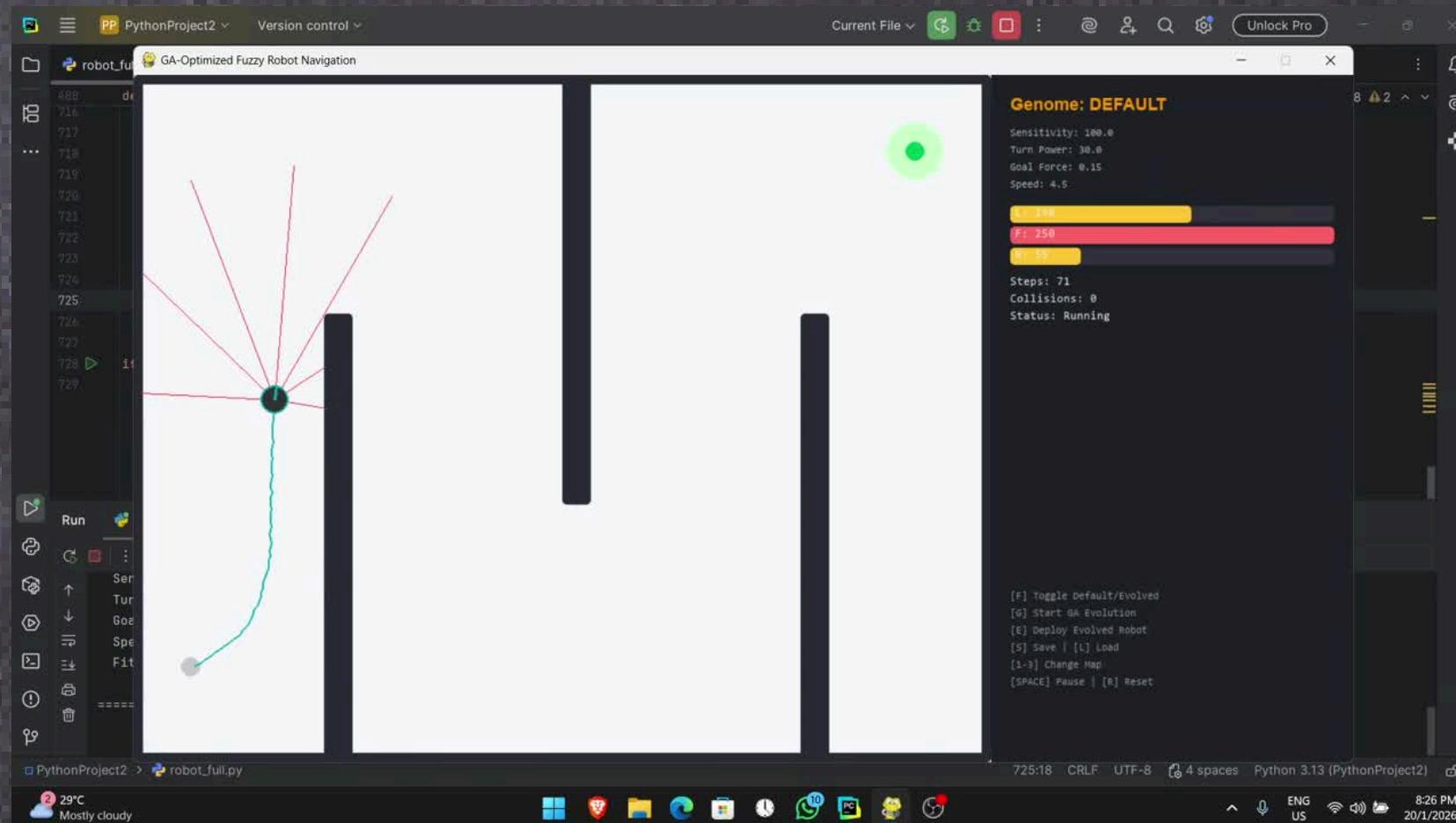
EACH MAP EVOLVES ITS OWN OPTIMAL CONTROLLER

TRAINING PROCESS



NAVIGATION RESULTS

- ROBOT SUCCESSFULLY REACHES THE GOAL
- NAVIGATION PATH BECOMES SMOOTHER AFTER GA OPTIMIZATION
- OBSTACLES ARE AVOIDED EFFECTIVELY
- PERFORMANCE IMPROVES COMPARED TO DEFAULT FUZZY CONTROLLER



FUZZY VS GA-FUZZY



Parameter	Fuzzy	Fuzzy-GA
Sensitivity	100.0	141.0
Turn Power	30.0	40.0
Goal Force	0.15	0.08
Speed	4.5	6.0
Steps	405	262
Collisions	0	0

CONCLUSION

- HYBRID GA-FUZZY APPROACH
ENABLES INTELLIGENT NAVIGATION
- AUTOMATIC OPTIMIZATION IMPROVES
RELIABILITY AND EFFICIENCY

- SYSTEM PERFORMS WELL IN
DIFFERENT ENVIRONMENTS
- PROJECT OBJECTIVES
SUCCESSFULLY ACHIEVED

