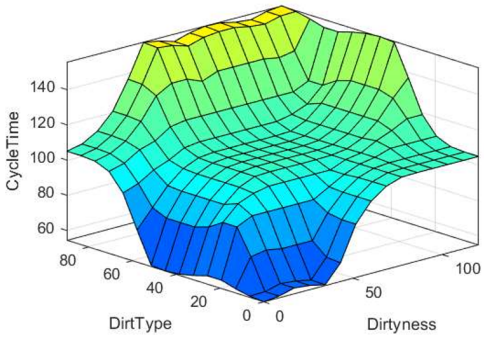
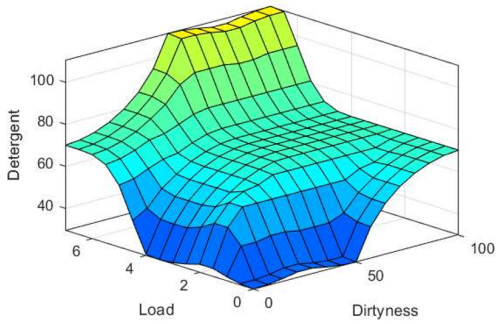
Question 1

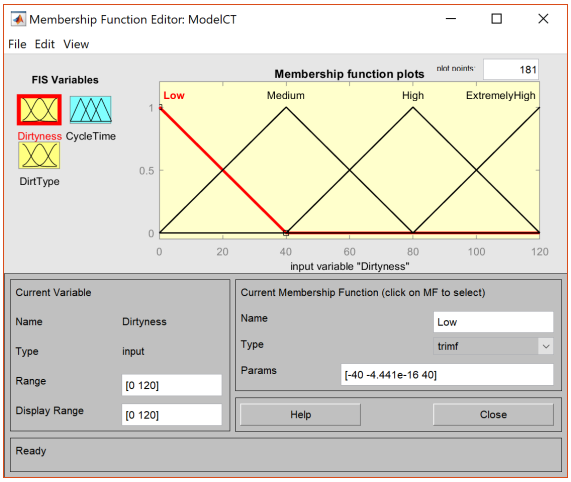
(a) Produce clear images for the surface plots for both Model CT and Model D, and provide screenshots for the input membership functions as well as the output membership functions. State your answers clearly for each model, separately.



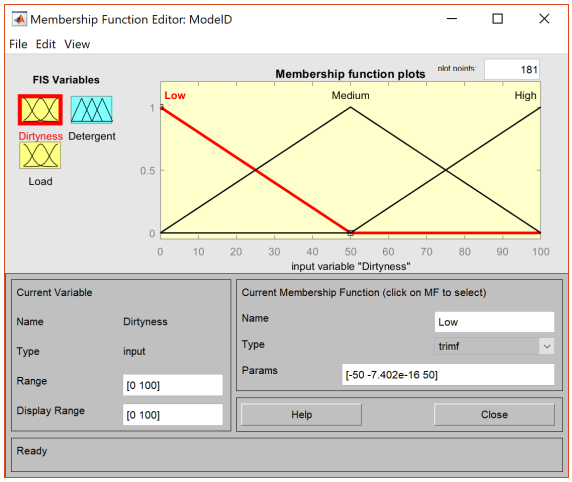
(a) ModelCT



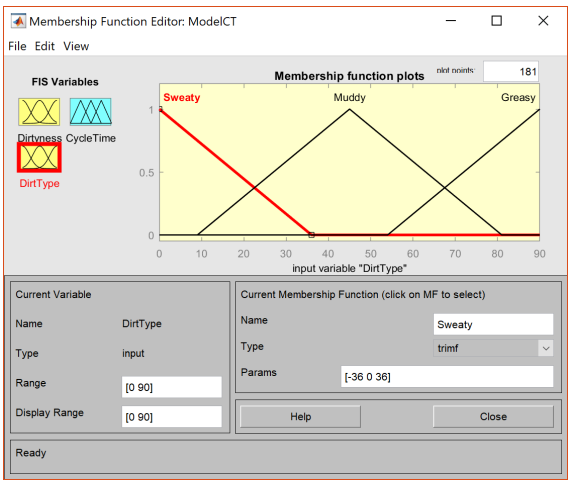
(b) ModelD



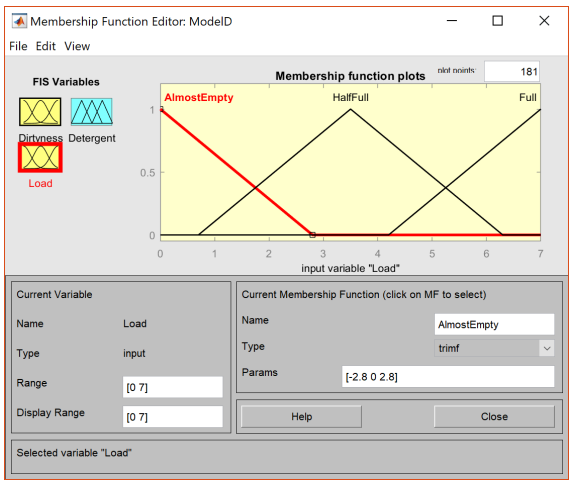
(a) ModelCT - Dirtyness Input



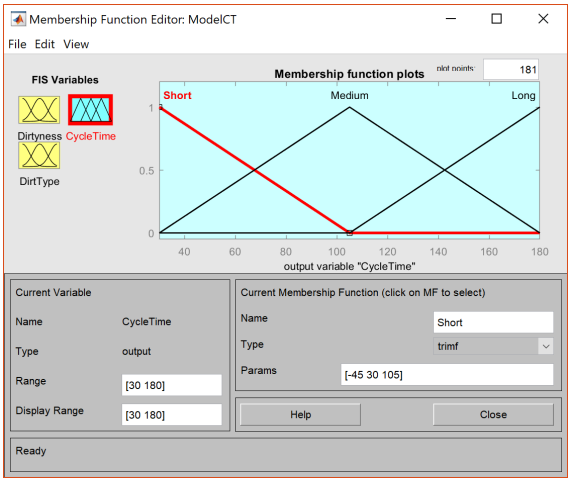
(b) ModelD - Dirtyness Input



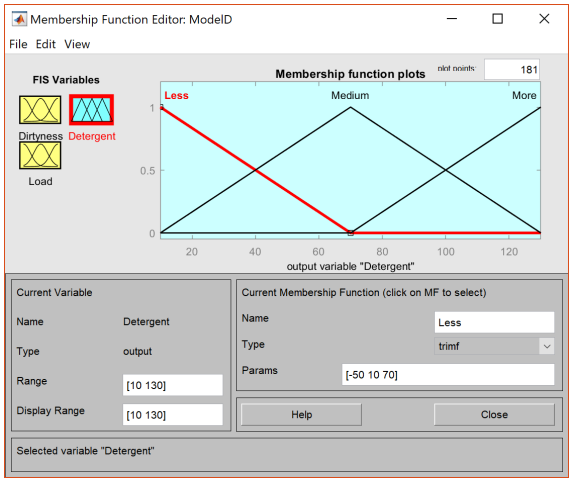
(a) ModelCT - DirtType Input



(b) ModelD - Load Input



(a) ModelCT - CycleTime Output



(b) ModelD - Detergent Output

(b) Modify the rule bases for both Model CT and Model D by reducing as much rules as possible, without changing the behaviour of the system too much. How would you explain the behaviour change while logically maintaining the rule base? If this is possible, give an example of your reasoning. Report the new rule bases, separately, and justify your decisions by briefly describing your motivation.

By ticking the not box, it is possible to avoid make rules seperately for each non-changing variable, reducing the number of rules from 9 to 6 for ModelD, and from 12 to 10 for ModelCT.

ModelD

Before:

(1) If (Dirtyness is Low) and (Load is AlmostEmpty) then (Detergent is Less) (1)
(2) If (Dirtyness is Medium) and (Load is AlmostEmpty) then (Detergent is Less) (1)
(3) If (Dirtyness is High) and (Load is AlmostEmpty) then (Detergent is Medium) (1)
(4) If (Dirtyness is Low) and (Load is HalfFull) then (Detergent is Less) (1)

(5) If (Dirtyness is Medium) and (Load is HalfFull) then (Detergent is Medium) (1)
(6) If (Dirtyness is High) and (Load is HalfFull) then (Detergent is Medium) (1)
(7) If (Dirtyness is Low) and (Load is Full) then (Detergent is Medium) (1)
(8) If (Dirtyness is Medium) and (Load is Full) then (Detergent is More) (1)
(9) If (Dirtyness is High) and (Load is Full) then (Detergent is More) (1)

After:

(1) If (Dirtyness is not High) and (Load is AlmostEmpty) then (Detergent is Less) (1)
(2) If (Dirtyness is High) and (Load is AlmostEmpty) then (Detergent is Medium) (1)
(3) If (Dirtyness is Low) and (Load is HalfFull) then (Detergent is Less) (1)
(4) If (Dirtyness is not Low) and (Load is HalfFull) then (Detergent is Medium) (1)
(5) If (Dirtyness is Low) and (Load is Full) then (Detergent is Medium) (1)
(6) If (Dirtyness is not Low) and (Load is Full) then (Detergent is More) (1)

ModelCT

Before:

(1) If (Dirtyness is Low) and (DirtType is Sweaty) then (CycleTime is Short) (1)
(2) If (Dirtyness is Medium) and (DirtType is Sweaty) then (CycleTime is Short) (1)
(3) If (Dirtyness is High) and (DirtType is Sweaty) then (CycleTime is Medium) (1)
(4) If (Dirtyness is ExtremelyHigh) and (DirtType is Sweaty) then (CycleTime is Medium) (1)
(5) If (Dirtyness is Low) and (DirtType is Muddy) then (CycleTime is Short) (1)
(6) If (Dirtyness is Medium) and (DirtType is Muddy) then (CycleTime is Medium) (1)
(7) If (Dirtyness is High) and (DirtType is Muddy) then (CycleTime is Medium) (1)
(8) If (Dirtyness is ExtremelyHigh) and (DirtType is Muddy) then (CycleTime is Long) (1)
(9) If (Dirtyness is Low) and (DirtType is Greasy) then (CycleTime is Medium) (1)
(10) If (Dirtyness is Medium) and (DirtType is Greasy) then (CycleTime is Long) (1)
(11) If (Dirtyness is High) and (DirtType is Greasy) then (CycleTime is Long) (1)
(12) If (Dirtyness is ExtremelyHigh) and (DirtType is Greasy) then (CycleTime is Long) (1)

After:

(1) If (Dirtyness is Low) and (DirtType is Sweaty) then (CycleTime is Short) (1)
(2) If (Dirtyness is Medium) and (DirtType is Sweaty) then (CycleTime is Short) (1)
(3) If (Dirtyness is High) and (DirtType is Sweaty) then (CycleTime is Medium) (1)
(4) If (Dirtyness is ExtremelyHigh) and (DirtType is Sweaty) then (CycleTime is Medium) (1)
(5) If (Dirtyness is Low) and (DirtType is Muddy) then (CycleTime is Short) (1)
(6) If (Dirtyness is Medium) and (DirtType is Muddy) then (CycleTime is Medium) (1)

(7) If (Dirtyness is High) and (DirtType is Muddy) then (CycleTime is Medium) (1)

(8) If (Dirtyness is ExtremelyHigh) and (DirtType is Muddy) then (CycleTime is Long) (1)

(9) If (Dirtyness is Low) and (DirtType is Greasy) then (CycleTime is Medium) (1)

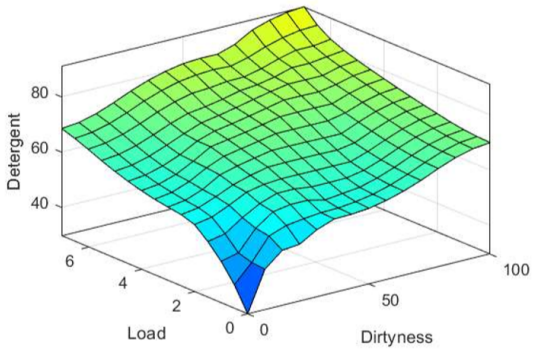
(10) If (Dirtyness is not Low) and (DirtType is Greasy) then (CycleTime is Long) (1)

(c) What kind of inference system did you implement for Model CT? Explain your answer by giving reason.

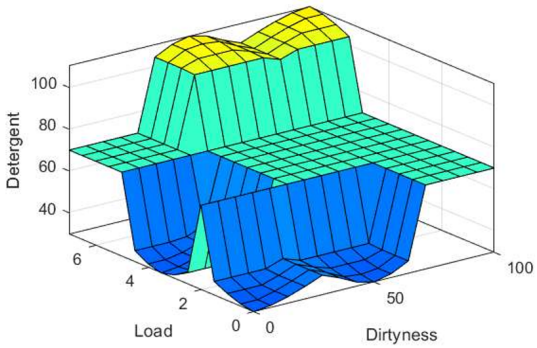
A Mamdani-type rule based inference system. The consequents are represented as fuzzy sets, the aggregation is performed on output fuzzy sets by taking the union.

(d) Try decreasing and increasing the overlap between both the input and output fuzzy sets for Model D. How does this influence the behaviour of the system? Explain briefly.

Increasing overlap makes the surface of the modal look more flat. Decreasing overlap decreases the complexity of the surface.



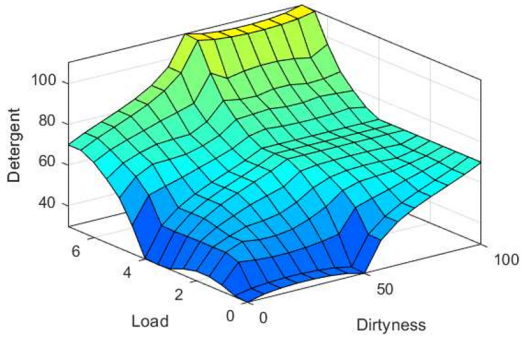
(a) ModelD - Increased Overlap



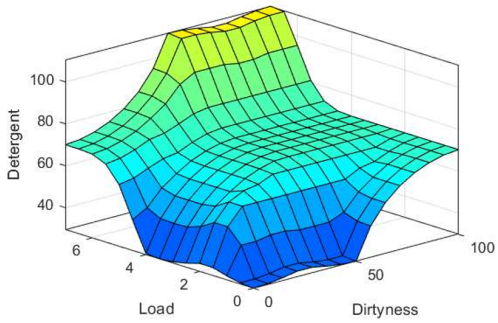
(b) ModelD - Decreased Overlap

(e) Change the settings according to the following parameters one at a time. How does this influence the behaviour of the system? Explain the meaning of the setting and describe your observations briefly. After each change, go back to the default settings.

(i) Aggregation = sum:

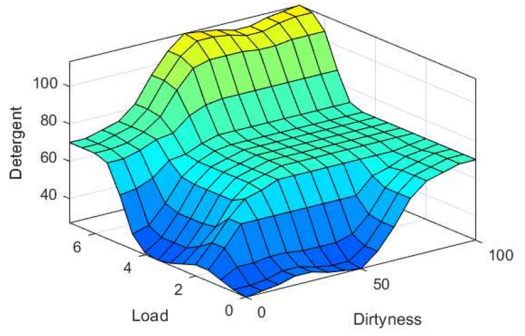


(a) ModelD - Aggregation = sum

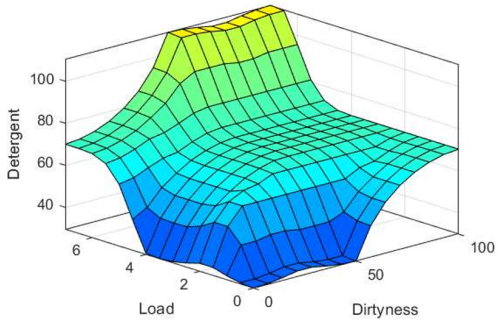


(b) ModelD - Original

(ii) Defuzzication = bisector:

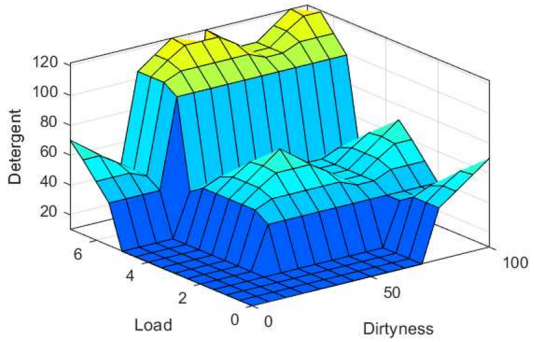


(a) ModelD - Defuzzication = bisector

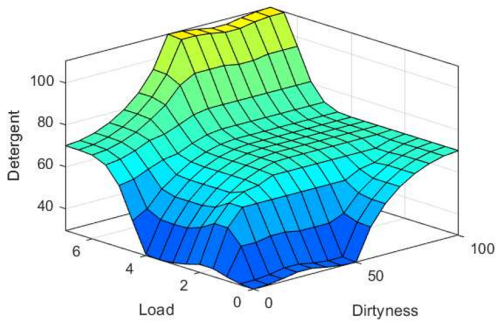


(b) ModelD - Original

(iii) Defuzzication = SoM:

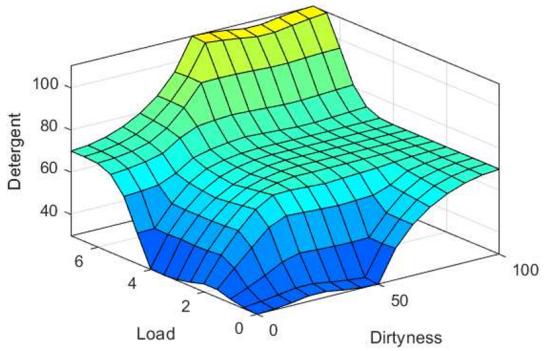


(a) ModelD - Defuzzication = som

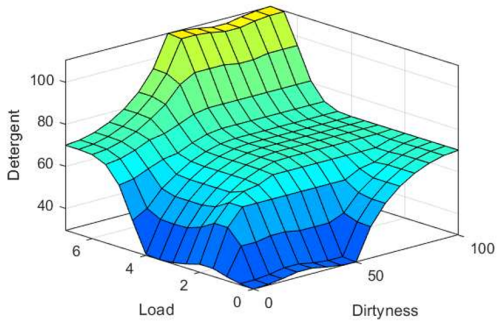


(b) ModelD - Original

(iv) T-norm = prod:



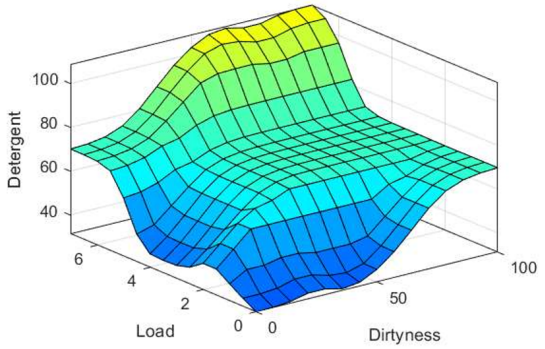
(a) ModelD - T-norm = prod



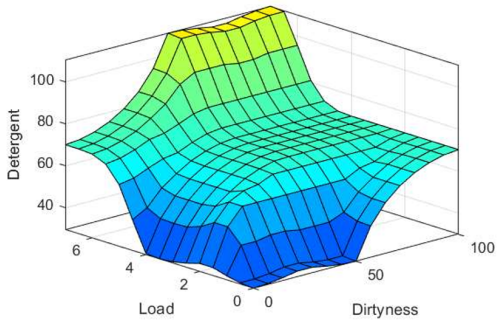
(b) ModelD - Original

(f) Change the input membership functions to be Gaussian rather than triangular for both inputs of Model CT. How does this influence the behaviour of the system? Explain briefly.

The membership level of an input variable that lies further away from the linguistic term is decreasing slowly at first, but the further it moves away, the faster it decreases, opposed to the immediate linear drop of membership.



(a) ModelD - MF = gaussian



(b) ModelD - Original

Question 2

(a) Show the input and output membership functions and the surfaces of your nal (most preferred) system for the following 2 inputs - 1 output combinations: [Dirtiness, DirtType, CycleTime], [Load, Dirtiness, CycleTime] and [Load, DirtType, Detergent].

(b) How did you design the membership functions for the input variables? Why? (Consider the number of fuzzy sets, type of fuzzy sets, the support and the core of the fuzzy sets)

(c) What are the rules you created? Describe your reasoning.

(d) What are the settings for this system? Why do you prefer these settings? (Consider inference type, T/S-norm, aggregation, implication and defuzzication)

(e) By analyzing the surfaces in 2(a), discuss whether you have designed a washing machine that can solve the customers complaints.

(f) How can you further improve your design and why?