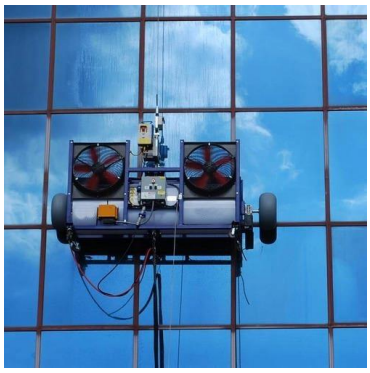
Designing Intelligent Systems - Report Pane Relief Soorya Sriram MDM18B049

1. Apply different levels of intelligence one by one to your chosen system and explain with respect to functions of the system.

The levels of intelligence classification help to analyse how the system form, function and behaviour changes dynamically real time with the environment. Decision making is done by identifying factors that cause the system to cross the threshold limit and make appropriate changes to the structure, form and function so that the behaviour is help to adapt to a wide variety of environments. This is done by taking into account the information intensity acquired using sensors placed in the subsystems and interaction between the sub agents to achieve the collective goal.

System: Robotic Arms placed on a platform traversing down the side used for cleaning windows of high-rise buildings. It comprises of robotic arms, a platform, a temporary water storage tank and is provided continuous electricity and water from the top connected via wires, pipes and ropes to hold the entire system together.

Functions of the System:



i) Efficiently clean the windows of high-rise buildings
ii) Maintain its horizontal and vertical bearing of the platform at all times
iii) Temperature, clean water and electricity regulation
iv) Maintain optimum distance between robotic arms and windows as well as other platforms taking into account the different adverse windows conditions

By aptly describing the different levels of intelligence for the system we are able to identify the interaction, roles and responsibilities of each subagent considering the collective systems model.

The levels of Intelligence are as follows:

1. Level of Intelligence
   i) Information Handling – passive
   ii) Problem Notification – active
   iii) Decision Making – Intelligent Action
2. Location of Intelligence
   i) Intelligence at Object – embedded containing complete processing ability
   ii) Intelligence at remote – collection of subsystems to solve a problem
3. Aggregation Level of Intelligence
   i) Intelligent item – component level
   ii) Intelligent Container – product level

These levels of Intelligence when applied for our system is as follows:

1) **Information Handling:**
   i) The platform which consists of the robotic arms is already having a lot of weight. In addition to that if the water storage due to temporary water storage tank makes the entire system heavier, then the force of gravity acting on the system increases which affects the system equilibrium. Hence the total weight of the system is calculated and constantly checked against a threshold limit at regular intervals
   ii) This threshold limit is calculated depending on the height above sea level the system is currently at and the weather conditions like strong winds or hail storms which may additionally cause the system to be imbalanced or disoriented. Whenever the weather conditions become adverse and system loses its horizontal bearing information is stored and relayed back.
   iii) The platform is going to traverse the side of the wall. The cleaning is done for specific area. Data will continuously be updated so that finally the surface area coverage can be retrieved if required.

   iv) The distance between the wall and platform is continuously calculated to maintain optimum distance for cleaning.
   v) Time taken to cover a certain section of the building will also be continuously updated to better understand and improve its efficiency.
   vi) The speed at which the platform is reducing in height is calculated to make sure the system is within safety limits.
   vii) Data is collected on how much dust or dirt has been collected on different parts of the building. This is required to estimate how often and type of cleaning required whether once in three months or yearly.
   viii) There is filter placed in the cleaning subsystem which calculates the Ph and purity of the water source. If the calculated values are not within the range the purpose of cleaning would be a failure.
   ix) There will be temperature sensor calculating real time temperature of the system trying to keep the system always in optimum temperature and this is continuously returned back to the user.

2) Problem Notification:

i) The weight of the system must always be notified to the consumer as any excess weight can cause the entire to collapse from mid-air.

ii) If the water purity levels are not within the stipulated range, there would be a notification suggesting to stop the cleaning process and to try and change the source of water.

iii) Due to adverse weather conditions if the platforms disorient vertically or horizontally, all other subsystems will be discontinued via communication and the user will be immediately notified via an alert.

iv) If any subsystem fails to work, the subsystem immediately relays it to the subsystems and a warning signal of the specific reason of failure of the subsystem to the user for better maintenance.

v) If the system is operating on the emergency backup battery system, prompts are given at regular intervals to either stop or provide another electricity source.

vi) Due to long hours of functioning or sudden electrical surge the subsystems may heat up, which in turn causes the entire system to shut down and the system tries to resume its activities after a cooldown period.

vii) The robotic arms send a signal to the platform that it has completed its cleaning. This information is then processed by the platform before it resumes its traversal along the side of the wall.

3) **Decision Making:**
   i) The system resumes its cleaning process once it identifies or gets the signal from its subsystems that the bearing is correct and traversal is vertically downwards again.
   ii) It will automatically regulate the amount of water entering the system using the information calculated continuously by the sensors attached.
   iii) The emergency backup battery system is automatically used to power the system if the electricity source is not being provided constantly and stops all the processes and returns to its stable position if the battery level reduces beyond a limit.
   iv) The ON/OFF Button starts to blink and sounds will be used to alert the user in case of emergencies to provide override option if all the subsystems fail to react in time.
   v) If corners or sharped ledges are identified by the robotic arms, those areas will be covered at a slower rate so that all dust particles get removed.
   vi) Due to excessive heating, if all the subsystems shut down after a cooldown period the temperature at every subsystem will be relayed and checked if it is within a range before resuming activities.

4) **Intelligence at Object:**
   i) Lidar sensors used to calculate the distance between the window and platform will help the system adjust at regular intervals.
   ii) There will be sensor to always maintain the horizontal and vertical bearing. If the system gets disoriented, all other subsystems will be temporarily discontinued and sensor instructs the system to either try to get its bearing right or wait for the adverse weather conditions to pass.
   iii) The temperature sensor with the help of exhaust fans regulate the temperature of the system and shuts down the system in case of excessive heating thereby preventing the system from failing completely.
   iv) If the weight sensor reports a value that exceeds the limit, escape valves may be opened to release some water to maintain equilibrium of the system.
   v) Ph sensors in the filtering subsystem will continuously regulate the cleanliness of water that is being provided for the cleaning process.

5) **Intelligence in network:**
   i) Parallel functioning of the systems is maintained at all times. However due to excessive heat or electrical influx the system shuts down by default it will be coded to brought back to its initial position.
   ii) A database is maintained collecting real time data from each subsystem and systems are made to work in tandem.
   iii) If any system reports irregularities, the entire network will stop functioning till the problem is resolved by controlling the subsystems from a separate server.
   iv) In case of a failure of a subsystem, distress alerts will be sent to the user to indicate error in the system.
   v) The systems will be able to coordinate within themselves to clean areas that come under a conflict so that no portion gets missed.
   vi) Platforms will be able to coordinate with the other platforms to make sure they never function at the same vertical and maintain a safe distance between each one. This is done by using a proximity sensor to alert the systems. This is of utmost importance since failure of one such system should not lead to other systems getting affected.
6) **Intelligent Item:**
   i) The subsystems defined may achieve different configuration states and each subsystem if it attains equilibrium maximum efficiency will be achieved.
   ii) Low level intelligent subsystems will try to perform its limited duties independently and will report back if it fails to achieve its goal.
   iii) Resource utilization should be bare minimum and hence systems will take rests and stop functioning when other systems are working, thereby leading to distributed utilization of resources especially electricity.
   iv) The subsystems as a whole when they achieve the collective goal of cleaning a window is an intelligent item.
   v) This system as whole has the capabilities to handle information, process it, alert or provide notifications and make its own decisions as mentioned above for itself.
   vi) The system comprising of smaller subsystems works together to achieve the collective goal of efficiently cleaning the window. This is done by regulating the water and electricity supply, checking the water's Ph purity levels and temperature of the system, maintaining the vertical and horizontal bearing keeping the optimum distance between window and platform and traversing at a regular speed so to as maintain the overall equilibrium of the system and achieve the collective goal.

7) Intelligent Container:

i) The endeavor of cleaning windows involves many such systems working hand in hand as efficiently as possible to complete the cleaning process within the stipulated time frame.

ii) Removal or replacement of one such system will not affect the other systems when the cleaning process is considered as whole and hence it can be termed as an intelligent container or cleaning system.

iii) The systems are in continuous communication to be aware of adjacent systems location and bearing to prevent accidents using proximity sensors like collision or inefficiency by recleaning areas that have already been covered.

iv) IOT and cloud-based servers can be employed to trigger different systems to function at different times via message to message communication between the back-end server and the cleaning system.

v) If due to excessive sunlight, one system gets heated up information can be relayed back to the server which can then be used to communicate to the other systems, that cleaning is to be temporarily stopped.

The different levels of intelligence help us to analyse the duties and limitation of every subsystem and how it is important to gather and relay back information to the backend server as this input can be used to maximize the efficiency of other such systems which are part of the entire network.

2. Explain the important components of collective systems model and apply those principles in your chosen system. Analyze what emerges out if your chosen system has collective system behavior? (considering subsystems as agents)

Collective Systems Model works on the concept of 'Divide and Conquer'. It is one which consists of many subagents working independently towards a common goal. It is vital that each subagent is aware of their limited duties and there is not central coordinator to control or oversee the subagent activities.

Features of Collective Systems Model:

- Self-Organization
- Self-Assembly/Arrangement
- Rule Based Limited Intelligence
- Maintenance of distance
- Efficient completion of its individual work
- Agents aware of their limited responsibilities and do not infringe on other duties
- Continuous Communication and Interaction
- Collective execution by individual contribution of each subagent
- Interacts via signals (intentional) and cues (unintentional) and this creates positive (follow) and negative(repulse) feedbacks amongst the subagents.
- Stipulated work frames and provide appropriate signals to each other.
- Each agent in a Different configuration will give different results in both physical and cyber space.
- System may have different equilibrium states - greater equilibrium states more intelligent
- Functions executed in 'N' number of ways – subsystems of limited intelligence interact to achieve higher intelligence.
- Execute in wide range of environments

This systems model can be applied for our system as well.

Our system:

The system consists of 2-3 robotic arms on a platform and is used to clean windows of high- rise buildings.

The **subagents of this collective system** are

1) The robotic arms
2) The platform
3) Internal water cleaning/filtering temporary water storage system
4) Internal Battery System
5) Position Bearing system
6) Supervising/Notification System
7) Temperature Management System

The collective goal of the system would be to clean all the windows as efficiently and clean as possible.

Using collective systems model we are able to better to analyse and distribute the duties.

1) **The Robotic Arms Agent:**
    - The limited duty of the robotic arm is clean a specific area of the window,
    - It should maintain sufficient distance with its next corresponding arm so that it does not infringe into the other arm's area.
    - The robotic arms are to clean the windows in tangent and when there is greater dirt to clean for one arm the other is to interact with that arm and stop cleaning its portion once it has completed.
    - This can be achieved by using sensors between the robotic arms so to prevent to wastage of soap, water and electricity.
    - If bird nests or some other natural obstacles are encountered the robotic arm should convey to the platform subagent to stop its traversal midair till the hindrance is removed.
    - The robotic can convey a message to the platform once it has sufficiently cleaned the windows leading to positive feedback.
    - The robotic arm depending on the layout and on whether it is dry dusting or heavy cleaning with soap should aptly use the right brush or wiper so to reach corners and ledges which otherwise would be possible.

2) The Platform Agent

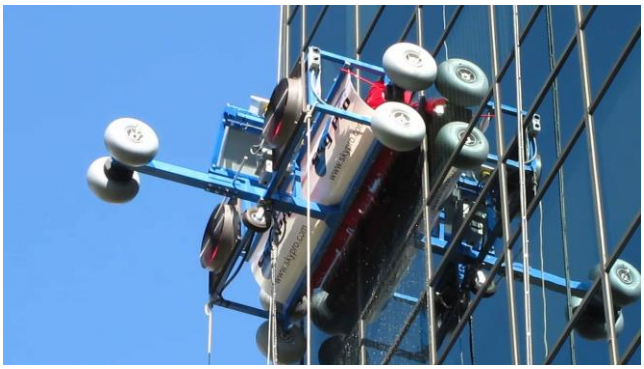
- The platform is another subagent in the system.
- Its primary duty is to traverse the vertical lane assigned to it from up to down carrying the robotic arms.
- There may be high winds due to which the platform may get disoriented from its horizontal initial bearing.
- When the sensors on the platform realizes that its bearing has changed, there should be interaction with robotic arms to stop cleaning and to configure its position first.
- Wireless transmission between platforms might aid the movement and traversal and allocated areas will be cleaned by each subsystem.
- If the platform realizes that its horizontal bearing is off, a signal may be sent to the robotic arms to stop cleaning (negative feedback).
- When the cleaning process is being executed, the platform subagent should stop its movement and wait for the signal from the arms before moving again.

3) Internal Cleaning Agent

- It is of utmost importance that the water being provided is 99% pure before being used to clean windows.
- Hence an internal cleaning subagent is present whose primary duty is to clean the water being passed through from the roof tank.
- Regulated amounts of water and specific amounts of soap is added before its interaction with the robotic arms.
- This regulation can be done using temperature and Ph calculating sensors so as to get higher effectiveness in the cleaning process.
- The robotic arms subagent and internal cleaning subagents works hand in hand so that when water is not required, this subagent stops the flow and if there is an excess of water flowing through the pipes it will send a distress signal to alert to reduce the water and open escape valves to release the excess water to prevent pressure from building up.
- If greater amounts flow it may lead greater pressure in the pipes causing it to burst or weight of the entire system increases and force of gravity acting on it would be greater.
- Depending on the activity of the cleaning system whether its dry dusting or heavy cleaning, it is the responsibility of this internal cleaning system to maintain the right composition and provide water at required intervals.

4) **Internal Battery Agent**
    - Internal Battery system is another subagent which is under operation all the time.
    - If there is sudden current outage or reduction, the role of the battery system comes into play which allows the subagents to work (positive feedback).
    - When it's not performing this duty, it should recharge so that it is able to perform its duty in times of emergency.
    - When the weather conditions become adverse it should have an override function to immediately terminate all other subagents to terminate its activities (negative feedback).
    - Furthermore, if the battery falls below a certain limit, the battery system should relay the information to stop all the other agents in their duties and settle at a stable position.
    - Different modes are available to maximize efficiency and for using it for long hours a balance is decided by this system depending on the requirements.
5) **Position Bearing Agent**
    - The position bearing system is an internal agent and its duty is to regularize the movement speed, make sure the platform subagent follows a straight line down and maintains the clearance height above the ground/ calculates the position at which the platform stops cleaning so as to resume the next day from the same position.
    - In case of emergency if the holding wires cut accidently this system will a loud distress call to alert all the passerby and people on site of cleaning.
6) **Supervisor Notification System**
    - This system has a clear role defined which is the integral system that takes into account all the alerts and signals from all the subagents and converts the signals obtained from sensors in binary to values that can be interpreted by the user.
7) **Temperature Management System**
    - It is responsible to maintain the internal temperature of the all the subagents of the cleaning system and provides a signal if the overall temperature is beyond safety limits of any of the subagent.

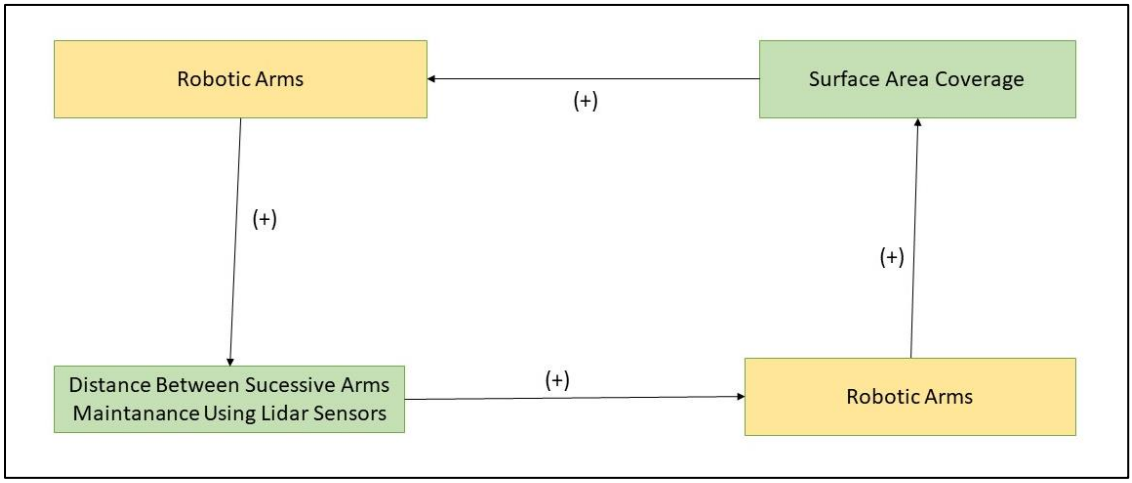
Hence these 7 subagents have their own duties to perform without infringing upon the other which leads to many equilibrium and configuration states which make the system intelligent.



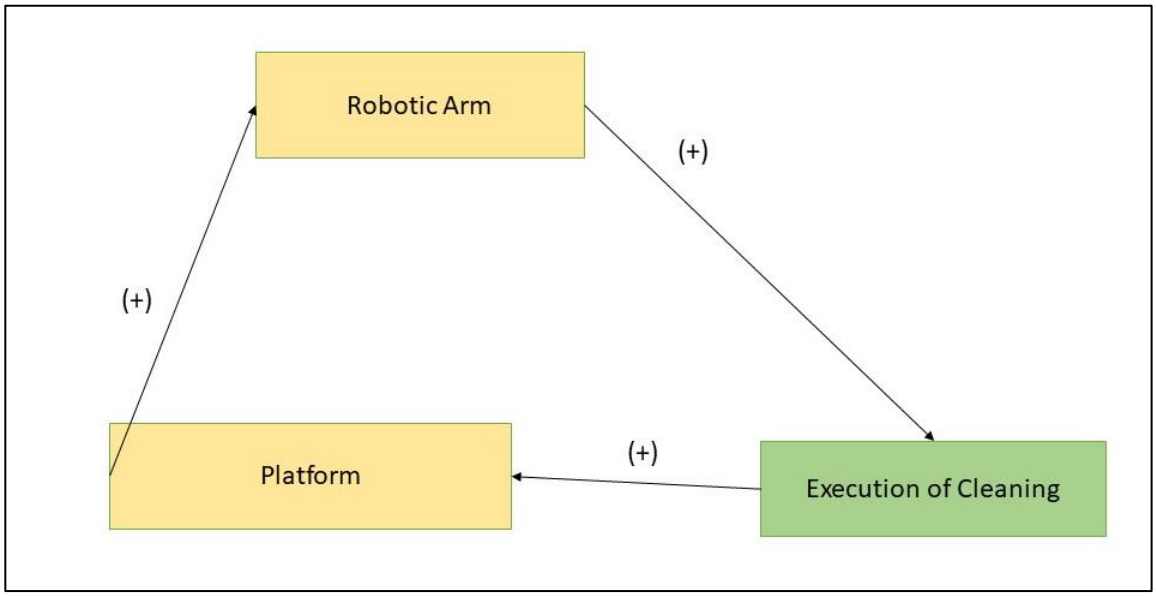
3. Define different feedback loops, identify them in your chosen system. Mention the suitable analogy/ metaphor for your system with respect to functions, operators and feedback loops.

Feedback loops are integral to identify the self-organization within a system. The following are the various interactions between the internal subsystems.

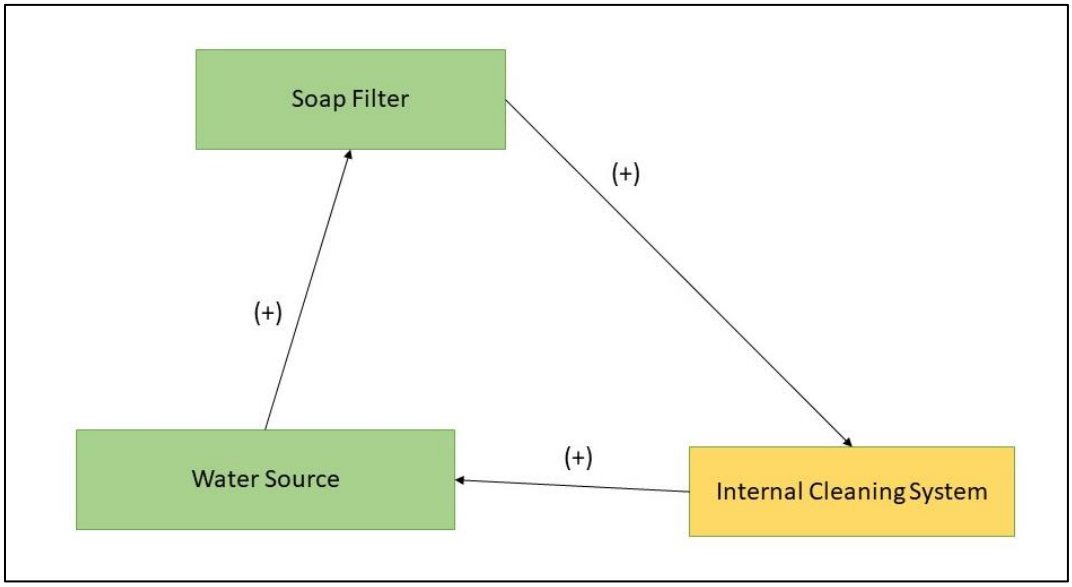
Positive Feedback Loops:



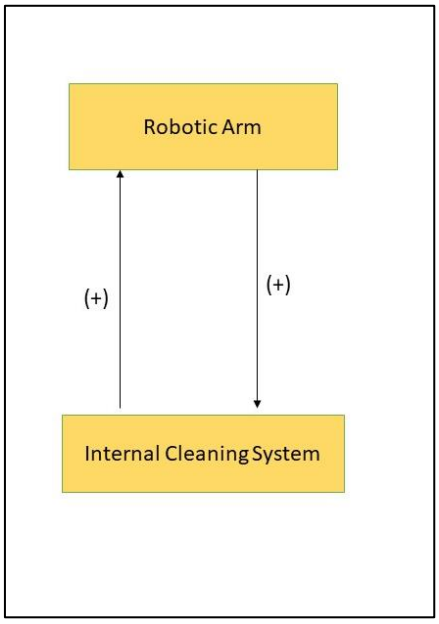
The robotic arms subsystem consists of 2 arms where sufficient distance is maintained between the arms so that maximum area can be covered while cleaning and the same areas are not cleaned twice unnecessarily wasting resources.



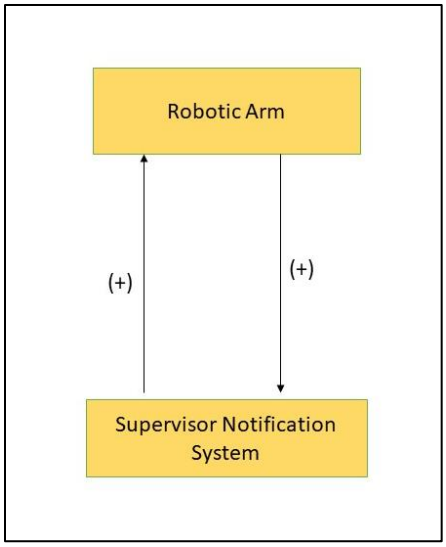
The robotic arm takes time to clean the windows. At this moment the platform remains stationary waiting for the robotic arm to complete its duty. Once it gets a signal from the arms that cleaning has been completed successfully the platform again begins to traverse along the side of the building.



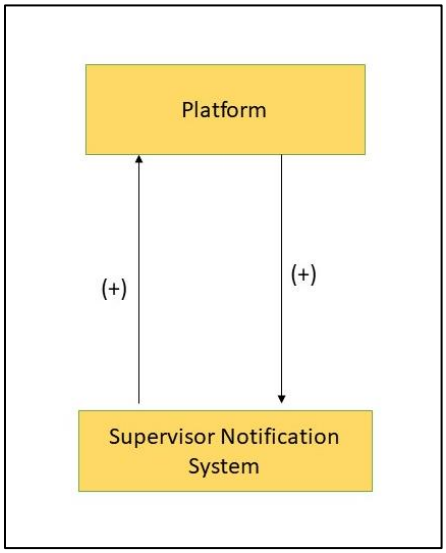
Water is obtained from the water source which is passes through a soap filter to test its Ph and purity and the internal cleaning system cleans the water adding required amounts of soap before this water is provided for cleaning for the robotic arms.



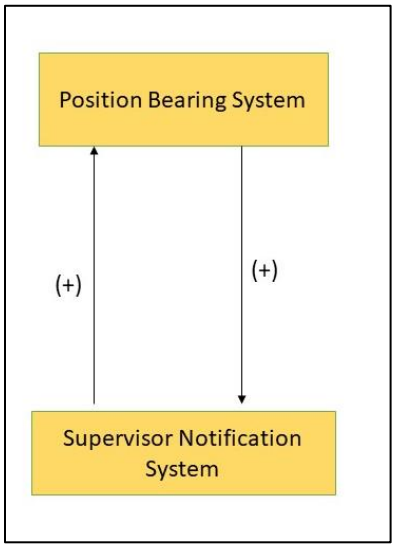
If the amount of water being stored in the temporary cleaning system increases in weight, it automatically regulates the amount of water flowing and if required opens the escape valves to let a bit water to flow to reduce the weight and therefore the force on the wires holding the entire system.



Data obtained from the robotic arm about time taken to clean a specific area, the amount of dust accumulated at that spot and distance between the arms and window is continuously updated real time.

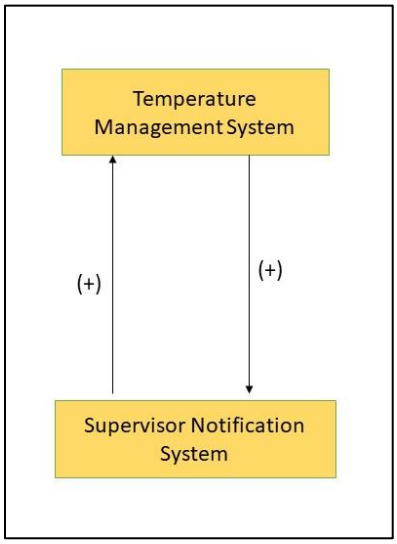


The platform traverses along the vertical direction and if it loses its vertical or horizontal bearing it sens information to the supiervisor notifcation system.

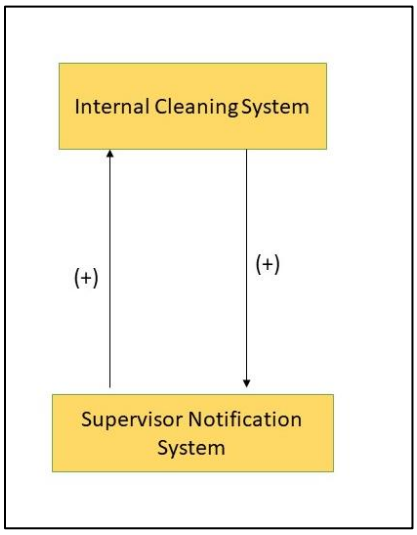


The position bearing system keeps track of the vertical height above sea level and makes sure the platform traverses in a vertical direction downwards. This information is relayed back

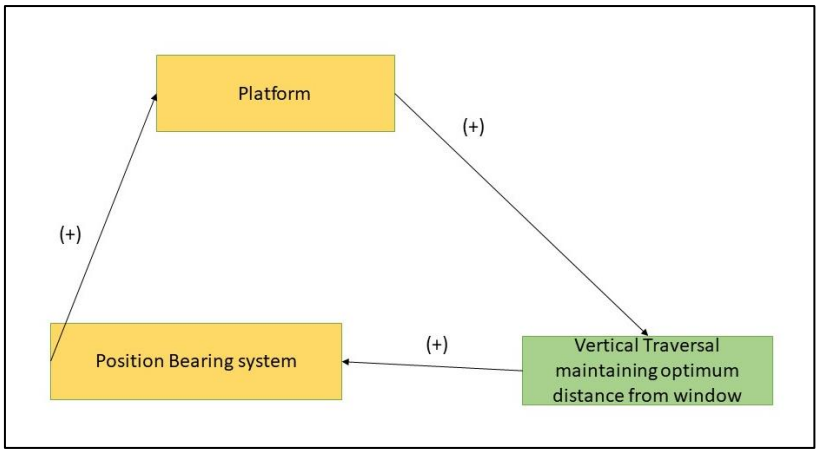
continously for regular updates about each system.



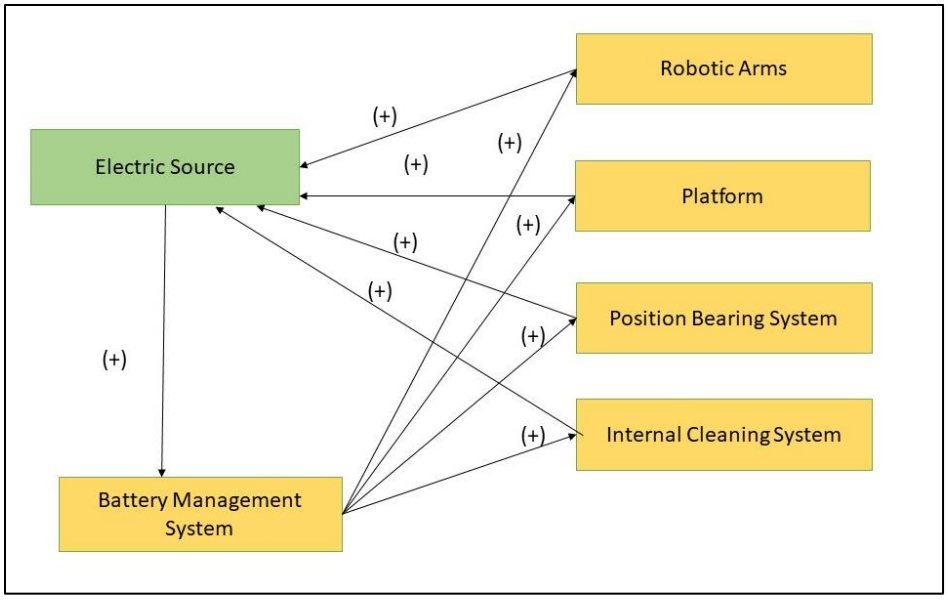
This interaction is one of the most important loops since the tempature management system continuously monitors the temperature of all the subsystems and if any of them cross the threshold limit it may lead to failure or accident. Hence this information is sent back to the user via the supervisor notification system.



If the water purity is not upto the mark after cleansing the internal cleaning system sends information to the supervisor notification system that the water quality is poor and to not continue th eprocess as it may erode the internal filter due to high salt or acid content.

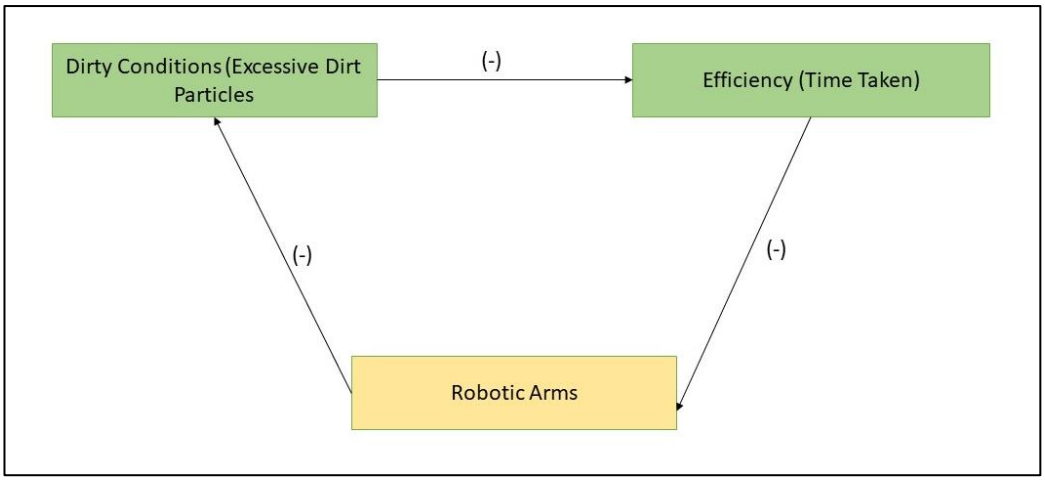


Vertical traversal is done by the platform from up to down along the building. The position bearing system helps it to maintain this vertical traversal whille the platform maintains its horizontal bearing. In this mode maximum efficiency can be achieved from the cleaning process.

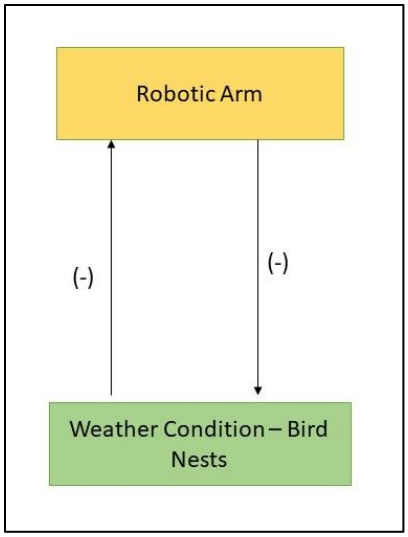


Constant electric power has to be provided for all the subsystems to function. The Battery Management system in cases there is a power fluctuation helps to maintain the duties being performed by providing emergency power for short period of times.

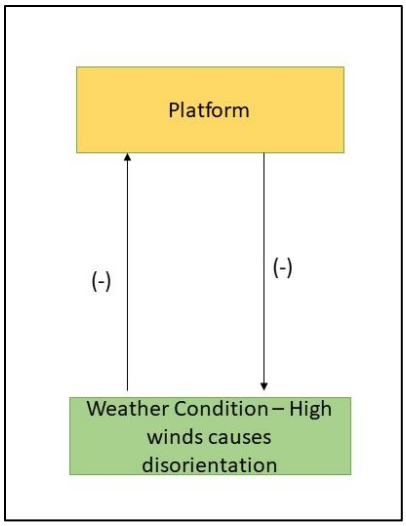
Negative Feedback Loops:



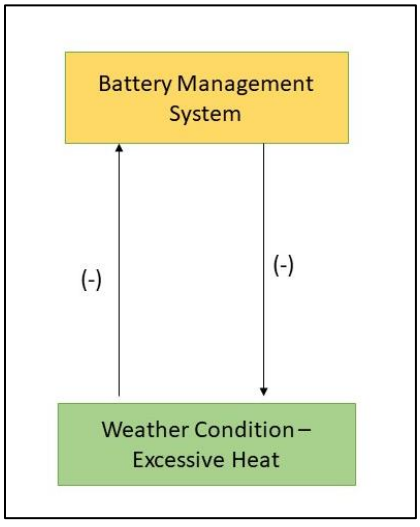
It will take greater time and effort from the robotic arms to clean a specific area if the windows are extremely dirty with excessive dirt. This dirt may even clog the brushes if care has not been taken hence it becomes important to clean windows at regular intervals.



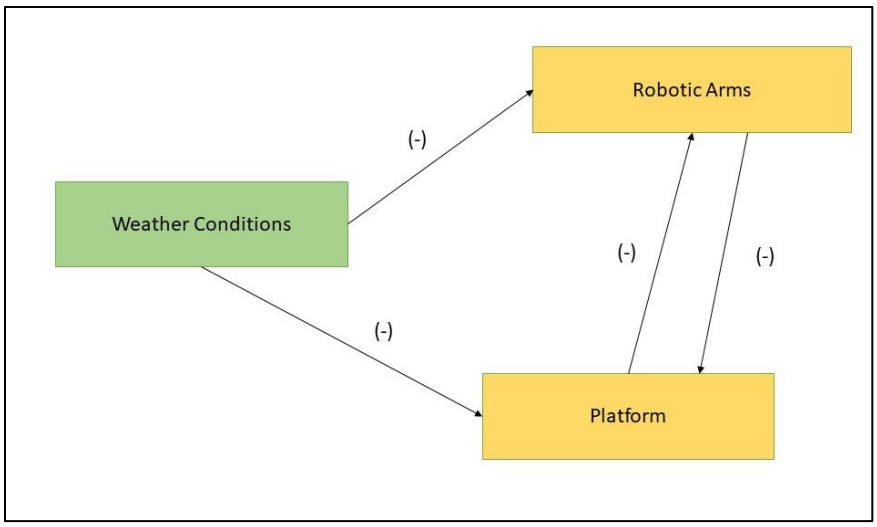
The robotic arm will stop functioning if the weather conditions affect its efficiency like the presence of bird nests as it hinders the cleaning process.



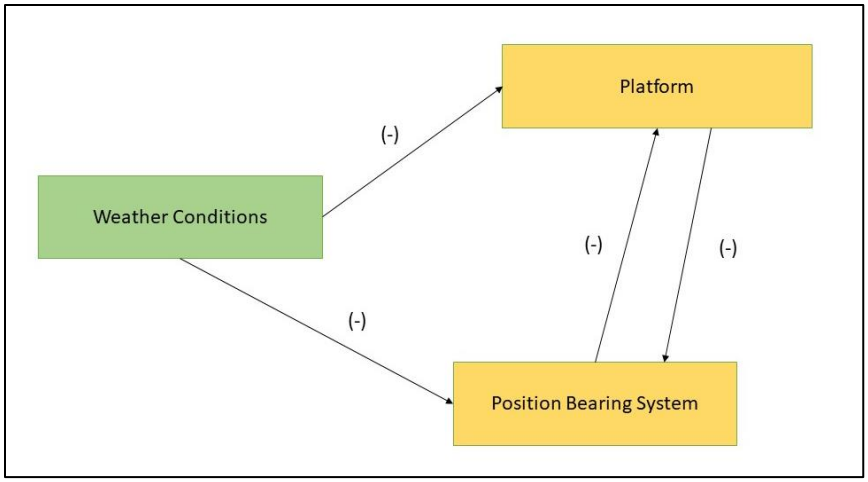
Strong winds may cause the platform to disorient itself and lose its horizontal bearing which affects the cleaning process hence all other subsystems discontinue their duties till this problem gets solved. There is a gyroscope sensor in place that's detects and corrects any imbalance caused.



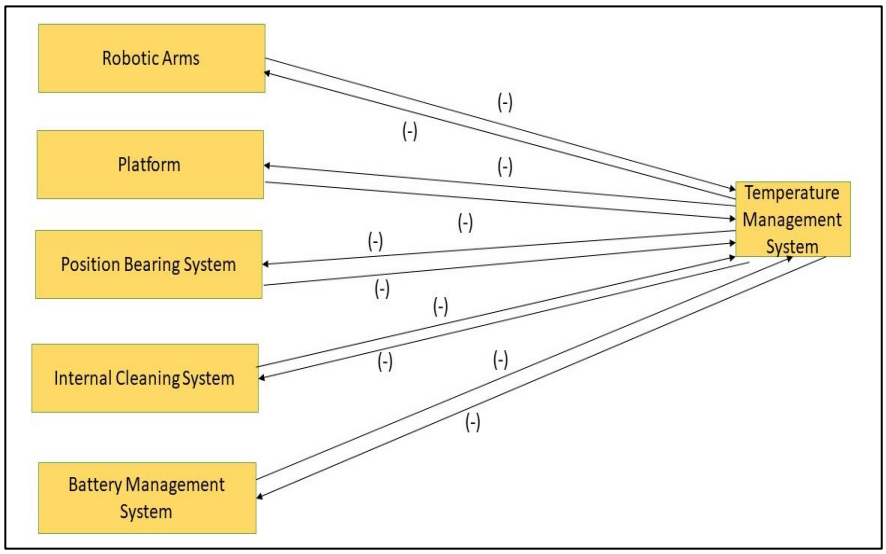
The battery management system provides continuous power to all the other subsystems and if there is excessive heat the battery may burn out which would be highly dangerous.



The weather conditions affect the efficiency of both the robotic arms and platform which leads to a negative feedback loop.



Harsh weather conditions affect the functioning of both these subsystems. The 2 subsystems have an interaction but its repulsive since the position bearing system keeps trying to rectify the path followed by the platform while moving downwards.



The temperature management system helps to regulate the internal temperatures and shuts down the system if any subsystem crosses any threshold limit.

Functions:

- Porcupines are known to come together during the cold weather for warmth but they are not be able to get close since their own spikes can cause harm. This is often known as the “Hedgehog/ Porcupine Dilemma”. We arrived at a similar dilemma where we would like the multiple platforms to traverse vertically down but having platform adjacent to each other does not allow the robotic arms to clean since contact or disturbance would be caused often. The entire cleaning process would have to be divided into lanes which reduces the efficiency.
- Similar to how spiders are able to maintain their vertical equilibrium while traversing down their silk, the function of the platform and position bearing system are to exactly that, that is to maintain its bearing.
  Our previous design which incorporated the caterpillar movement which moves along the surface by retraction in M shaped manner was found impossible to apply after doing the ethnography report.
  This was due to that fact that ledges, protrusions and shape of the building affected this horizontal traversal.
- The cleaning motion is done in a similar manner to a car windshield to ensure that the water drips down only along the sides.
- Camels store water temporarily in their humps. Similarly, a temporary water storage tank is present to store enough amounts of water at all times during the cleaning process.

Operators:

- Lidar Sensor is used to maintain optimum distance between the platform and windows so that the cleaning process would be efficient.
- Proximity sensors are used to maintain distance between various cleaning systems to prevent infringement.
- Temperature sensors in various subsystems help to regulate the temperature of the overall system which is of utmost importance.

Feedback Loops:

- Aggregation can be produced using models of positive & negative feedback loops - by assuming that fish displays four behavioral reactions that depend on the position and orientation of other fish:
- If there is another fish in its immediate neighborhood, the focal individual will move away to avoid collision (negative feedback) – platforms are made to stop or move away to prevent collisions using the position bearing system.
- If there is another fish at an intermediate distance, the focal individual will tend to align along its orientation – the robotic arms align itself with the platform so that toppling of the structure does not occur if the horizontal bearing is off.
- If there is another fish at a greater distance, the focal individual will tend to swim toward it (positive feedback) – the platforms are always interacting within a greater network to achieve maximum efficiency in the cleaning.

Note:

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