Constructive Artificial Intelligence
6COM1035

PART 1

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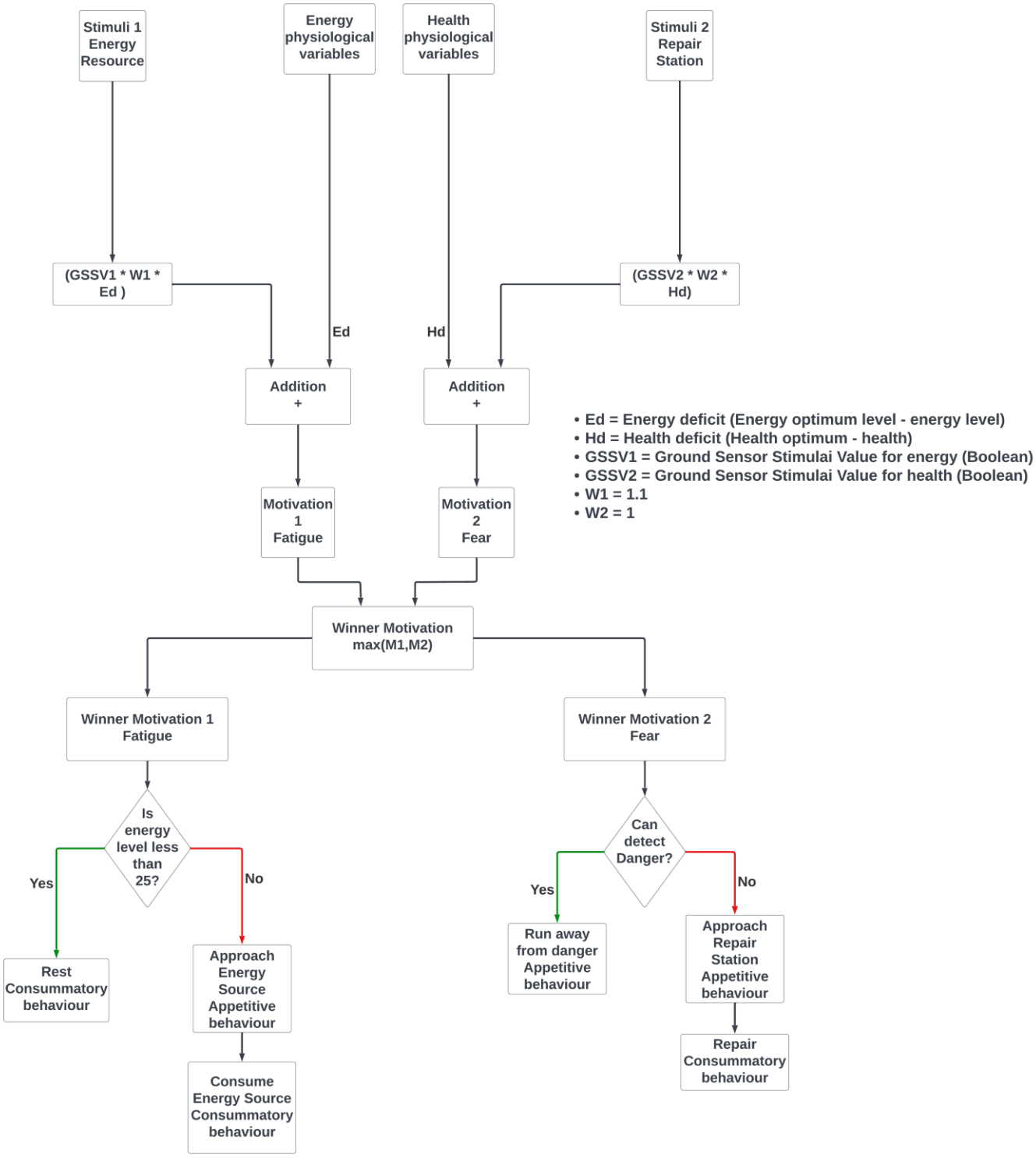
Architecture Diagram



Firstly, the 2 motivations get calculated by adding the deficits and external stimuli for each motivation respectively.

The deficit gets calculated by subtracting the current psychological variable value from the optimum psychological variable value. For example, the energy deficit (Ed) gets calculated by subtracting the current energy level from the optimum energy level.

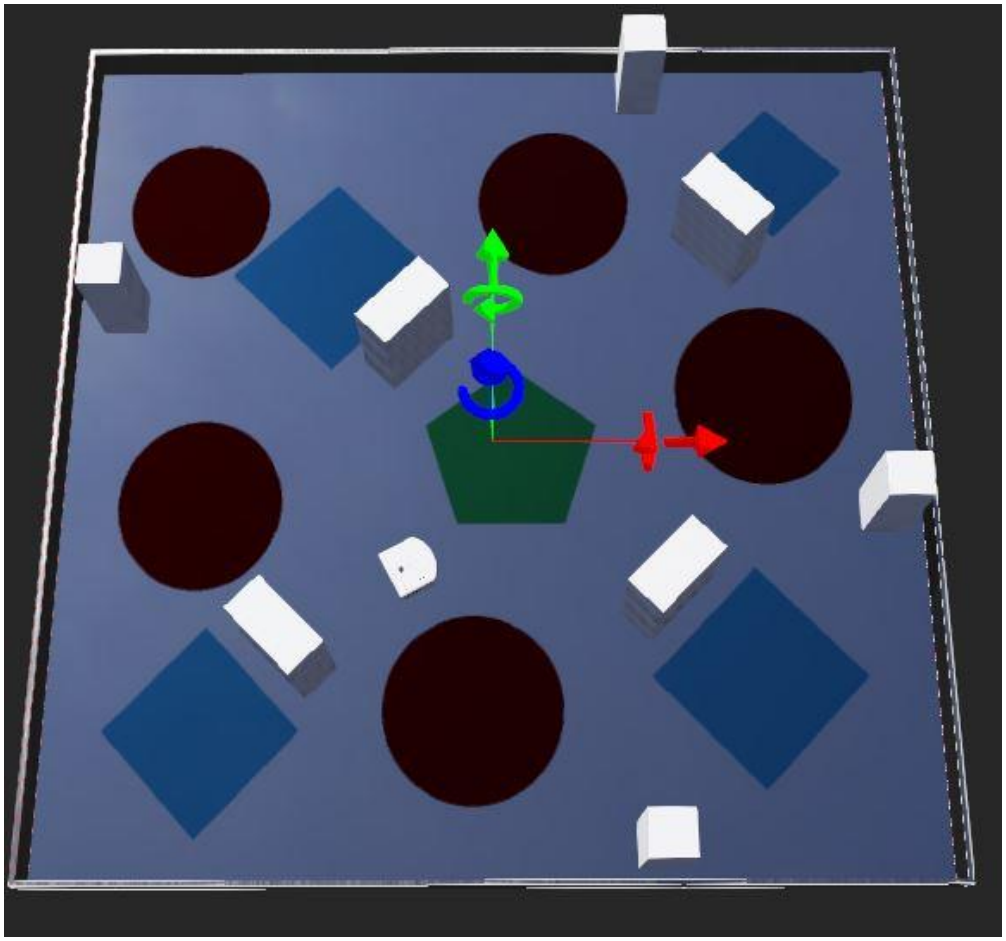
The external stimuli get calculated by multiplying the ground sensor stimuli value by a constant weight and the deficit of the psychological variable intended. The ground sensor stimuli values are Booleans which dictates whether any of the ground sensors sense the stimuli or not. The constant weight defines the bias or which psychological variable the robot prefers more.

The motivation then gets calculated for each psychological variable, in this case, we have 2 motivations fatigue and Fear based on the two psychological variables energy and health respectively. Afterward, the robot adapts to the winner take all methodology, by choosing the motivation with the highest value to pursue. The next step has 2 Scenarios:

First Scenario, the fatigue motivation wins, and since W1 (The energy constant weight) was set to 1.1, which is larger than W2, the robot is always biased towards fatigue motivation making it the most likely scenario. The robot then checks whether its energy level is less than 25 which is a couple of steps before death, if the energy level is under 25, the robot chooses to rest in its place activating the rest consummatory behavior. However, if the energy level is above 25, the robot prefers to search for an energy resource activating the approach energy resource appetitive behavior which leads to consuming an energy resource and activating the consume energy resource consummatory behavior.

Second Scenario, the Fear motivation wins, making the robot check whether he is in a dangerous spot by utilizing the ground sensors. If the robot senses a red patch underneath that means it's a dangerous spot, making it activate the run-away appetitive behavior which makes the robot steer away from the danger zone. Otherwise, if the robot doesn't sense a red patch underneath (danger), the robot prefers to search for a repair station activation by activating the approach repair station appetitive behavior which also leads to finding a repair station and activating the repair consummatory behavior.

Complex World Explanation



As can be seen above the complex world consists of 3 types of patches along with walls. The red patches refer to danger zones in which the robot's health (psychological variable) decreases. The green patches refer to repair stations in which a robot can restore his missing health. Finally, the blue patches refer to energy resources that restore the energy level psychological variable of the robot.

The complexity of this map increased drastically from the basic one as the number of red patches increased, the number of blue patches decreased, and only one green patch is located in the middle of the map. Furthermore, obstacles have been put on the map in the form of walls to deter the robot away from energy resources making them harder to find and forcing the robot to risk stepping on red patches to find an energy resource.

Qualitative Analysis

Observing the robot in both environments makes it clear that there is a behavioral change in the robot's action. The robot tends to explore most of the basic environment; however, it rarely explores more than half of the environment in the complex environment due to the constant presence of fear motivation which makes the robot run away from red patches (danger zones). Moreover, a common behavior of the robot is to step on red patches when at full health due to the absence of fear motivation which was mostly seen in the basic arena due to the presence of lots of repair stations. Additionally, it was noticed that the robot may even induce a resting behavior inside a red patch when at full health (health psychological variable) and by the time the resting behavior is done, the robot has a big fear motivation which makes it run away at a faster pace. However, the robot avoids dying in all simulations, as it avoids red batches on low health which ensures it always rests outside a red patch.

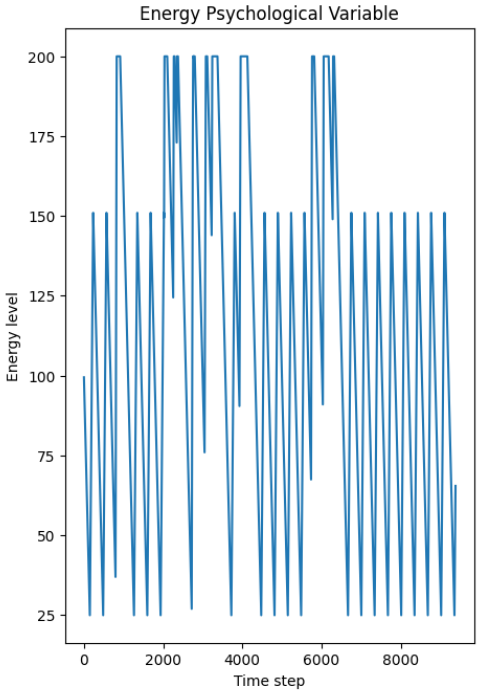
The robot clearly tends to resort to resting behavior much more frequently in the complex environment, than in the basic environment. The dominating behavior in the basic arena is clearly the fatigue motivation as it always searches for energy. However, in the complex environment Fear motivation is almost dominant due to the presence of only one repair station and lots of red patches.

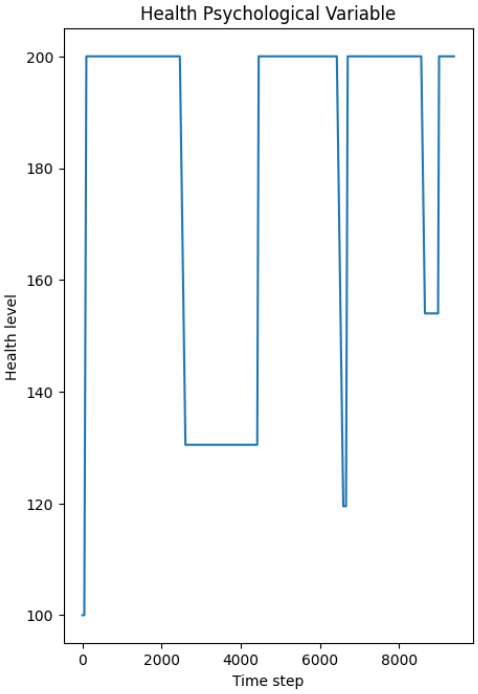
A behavior that was noticed only in the complex environment, is the robot moving in semi-circles around red patches due to the presence of obstacles and big red patches forcing the robot to move in certain directions. For example, the robot tends to move in a straight line whenever it's stuck between the wall and the red patch to the right in the complex environment. Another noticed behavior in the complex environment is that red patches and obstacles sometimes force the robot into corners preventing it from reaching the repair station in the middle of the complex map and inducing a constant fear motivation.

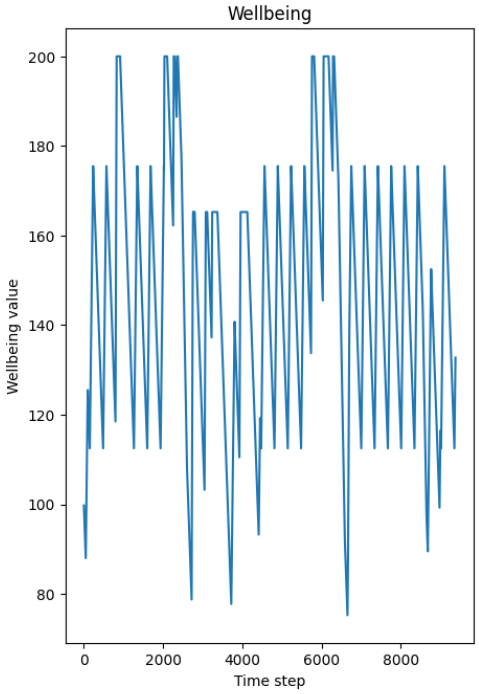
Quantitative Analysis

1. Basic Environment run number 1

```
Vitality = 0.7299529834842831
Vitality to the nearest two decimals = 0.73
Survival Time = 1 (never died)
```

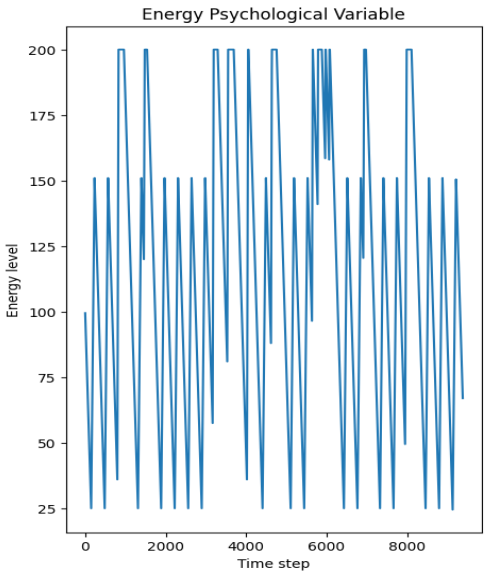


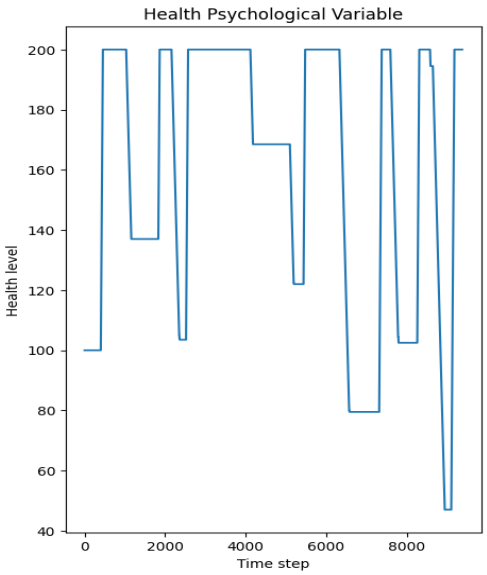


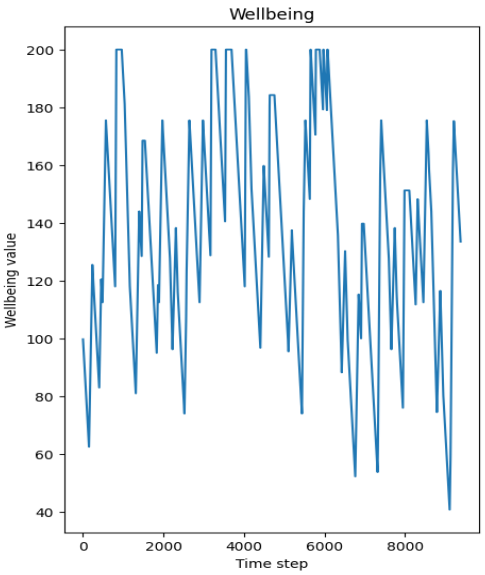


2. Basic Environment run number 2

```
Vitality = 0.6774257966535235
Vitality to the nearest two decimals = 0.68
Survival Time = 1 (never died)
```

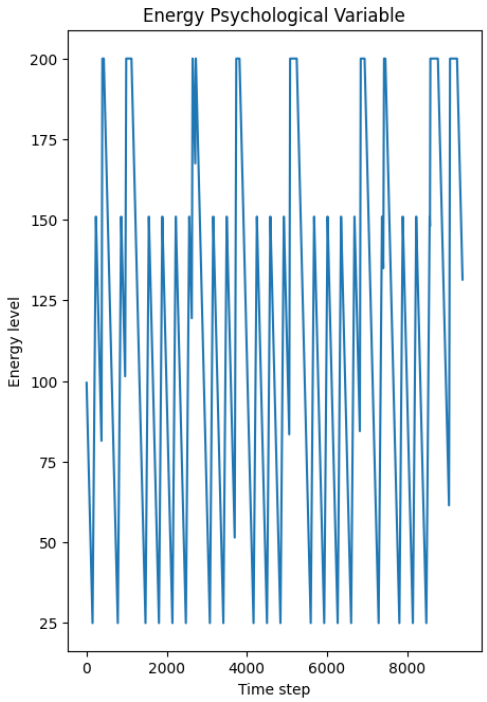


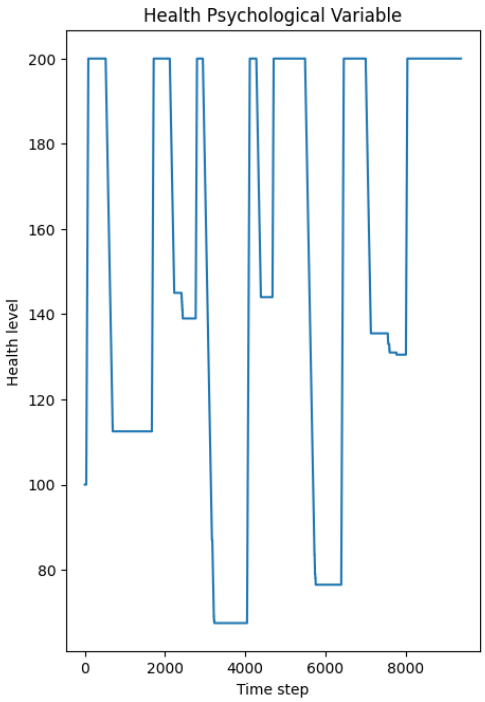


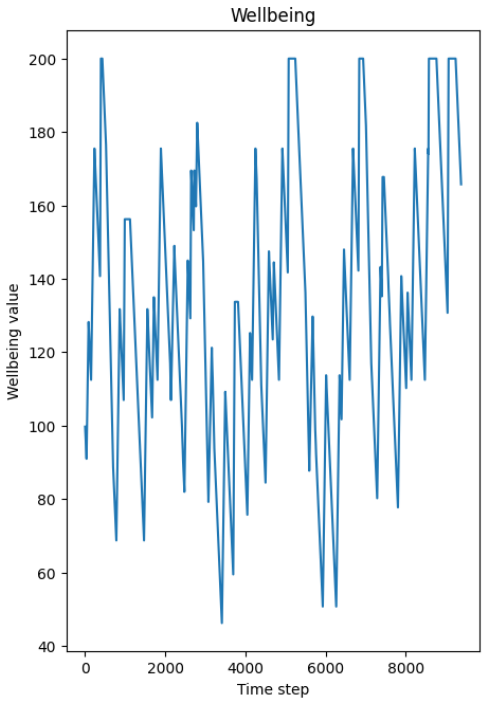


3. Basic Environment run number 3

```
Vitality = 0.6588014227858922
Vitality to the nearest two decimals = 0.66
Survival Time = 1 (never died)
```

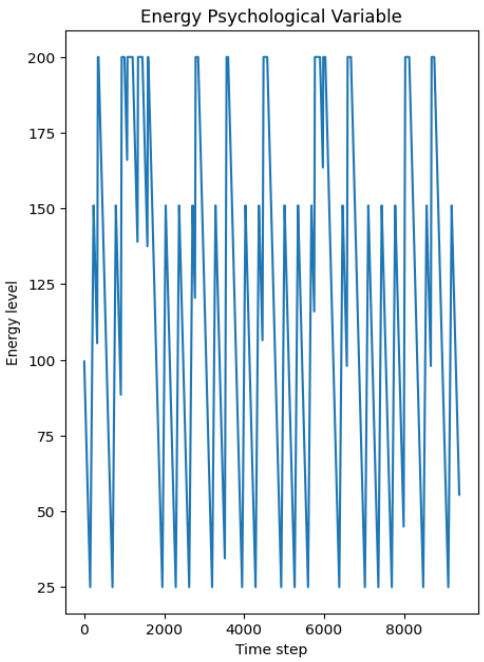


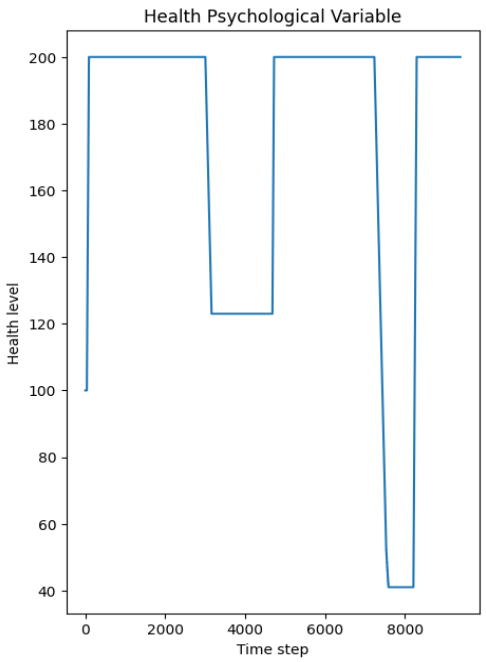


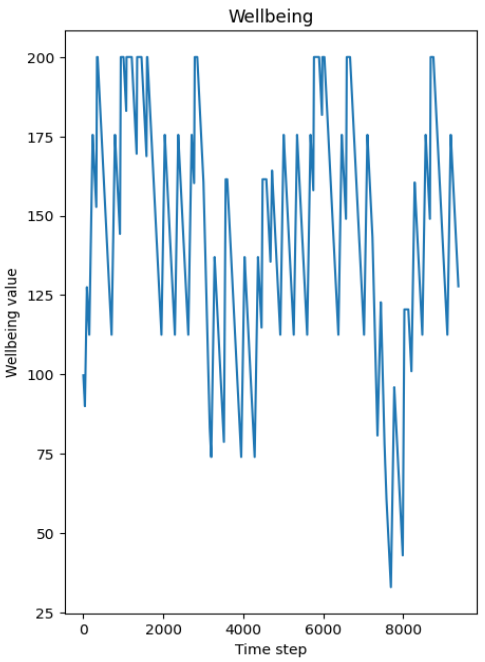


4. Basic Environment run number 4

```
Vitality = 0.71837063086104
Vitality to the nearest two decimals = 0.72
Survival Time = 1 (never died)
```

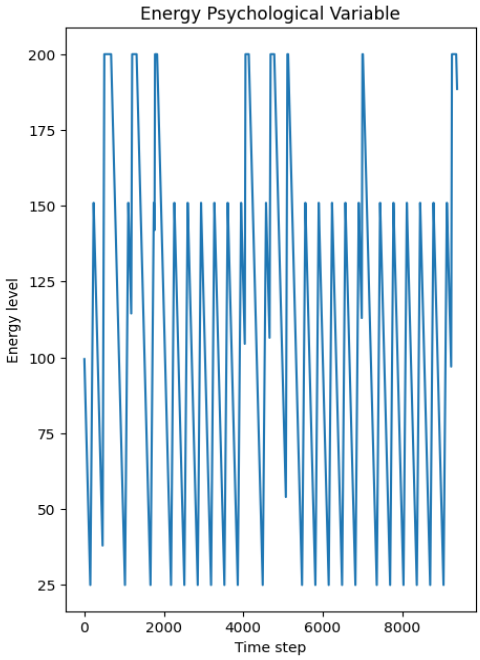


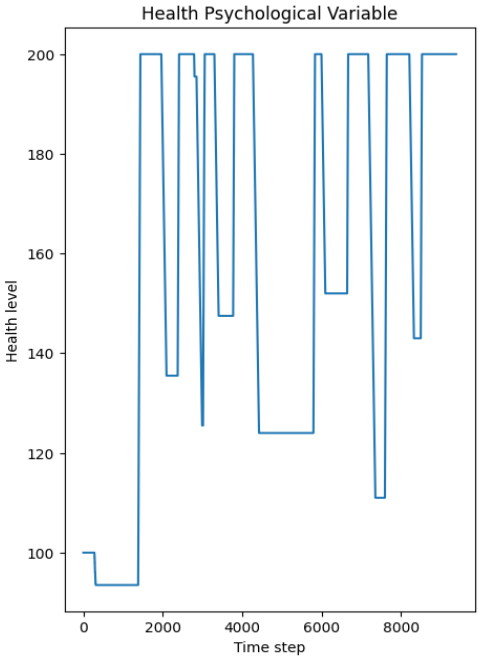


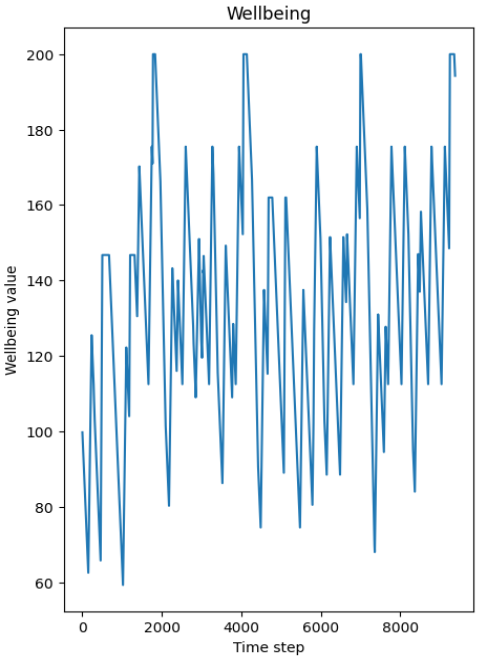


5. Basic Environment run number 5

```
Vitality = 0.6605089780477307
Vitality to the nearest two decimals = 0.66
Survival Time = 1 (never died)
```

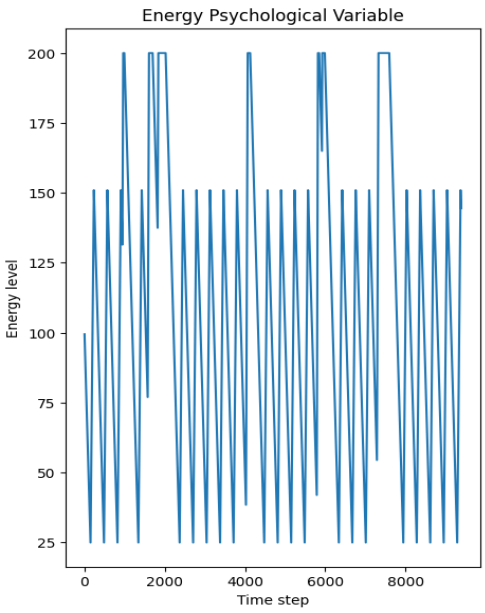


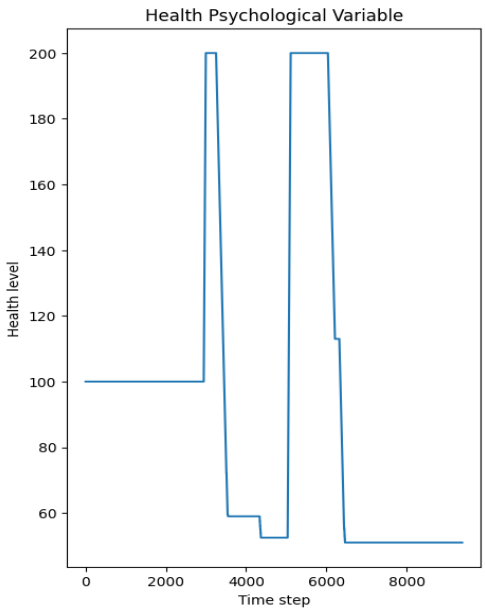


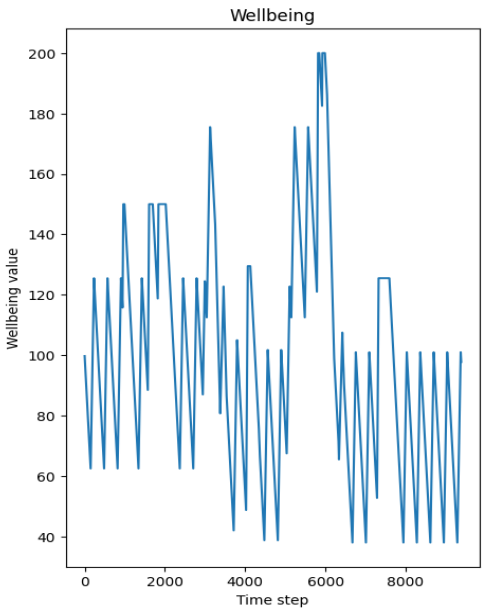


1. Complex Environment run number 1

```
Vitality = 0.49408277404923084
Vitality to the nearest two decimals = 0.49
Survival Time = 1 (never died)
```

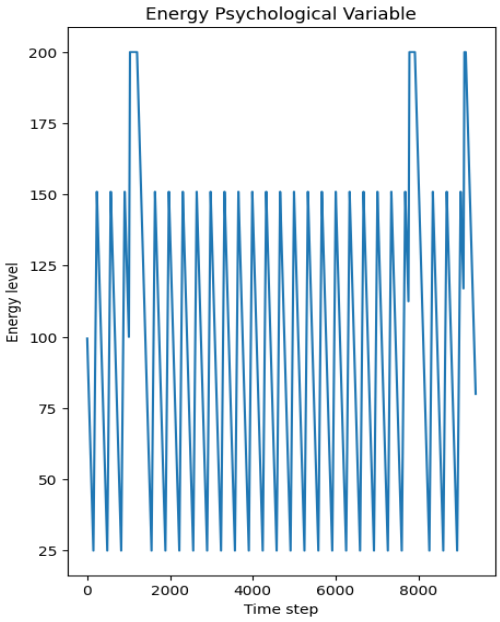


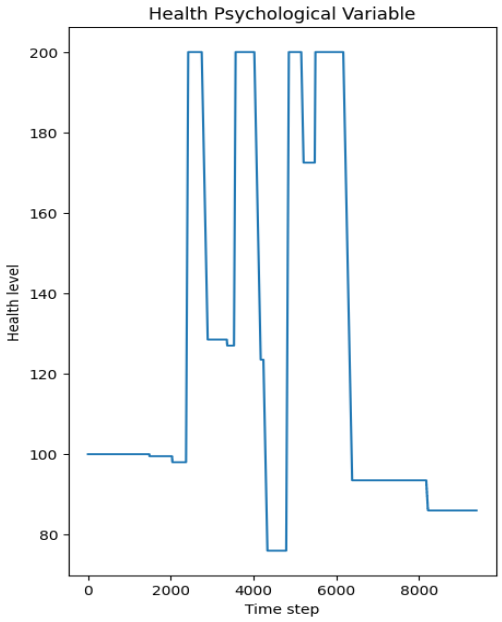


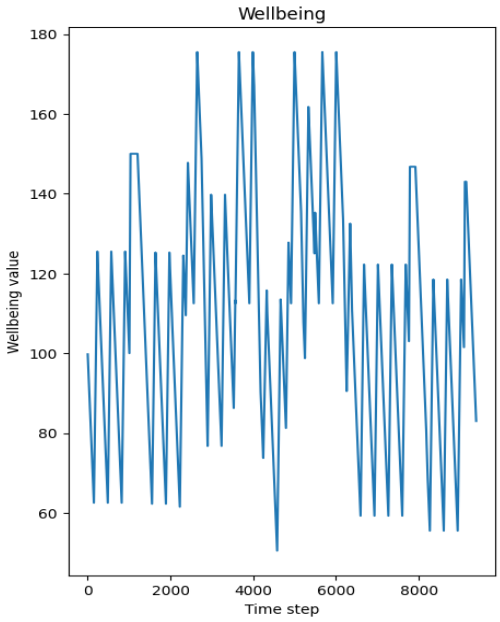


2. Complex Environment run number 2

```
Vitality = 0.5485665406326614
Vitality to the nearest two decimals = 0.55
Survival Time = 1 (never died)
```

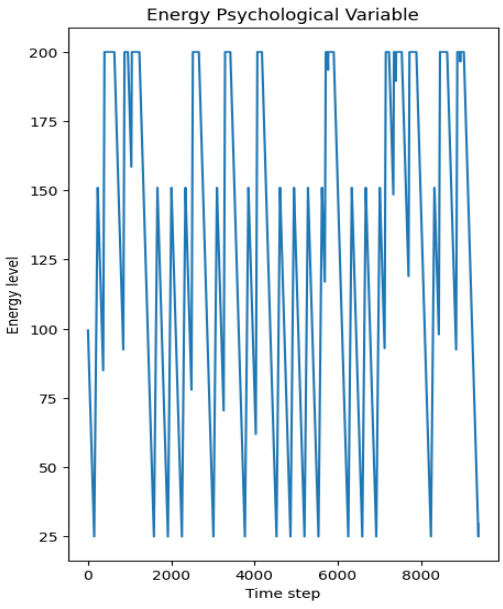


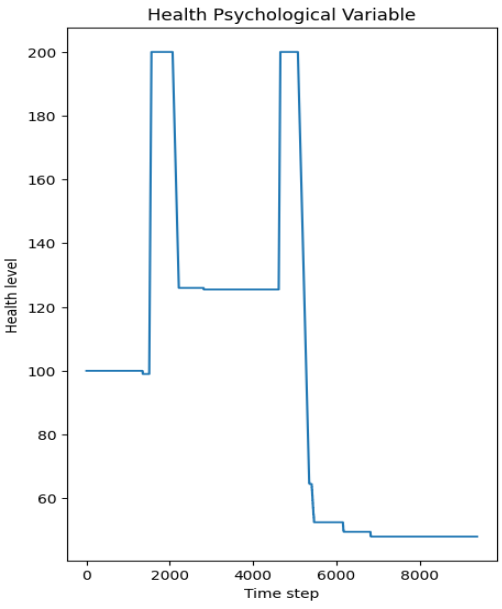


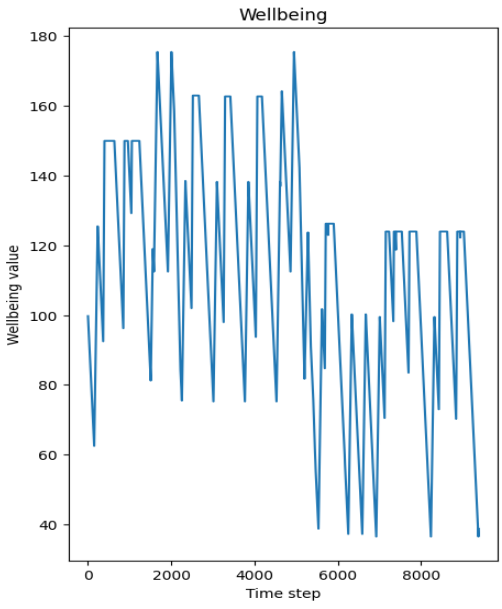


3. Complex Environment run number 3

```
Vitality = 0.5588872454961856
Vitality to the nearest two decimals = 0.56
Survival Time = 1 (never died)
```

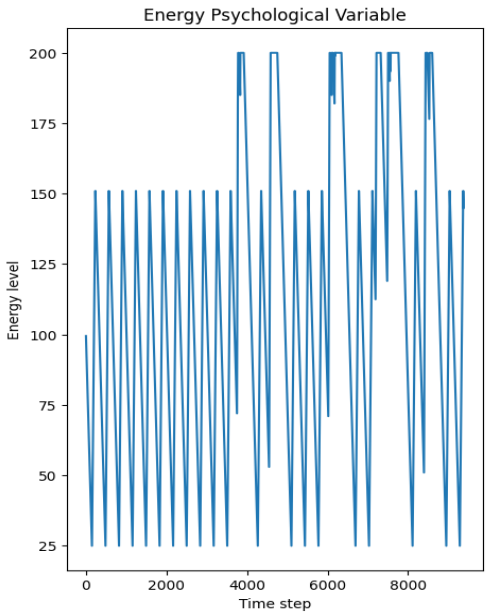


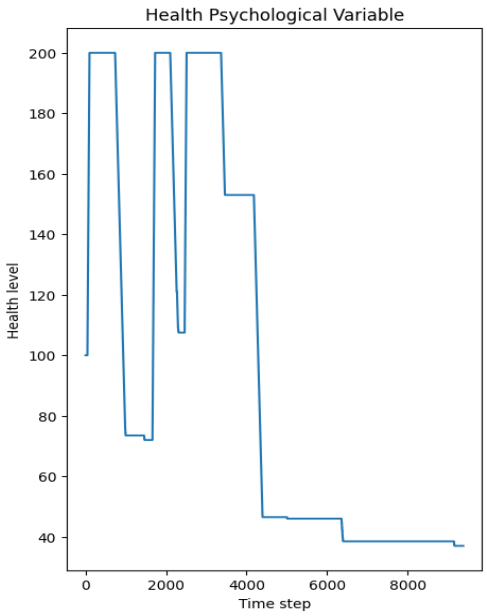


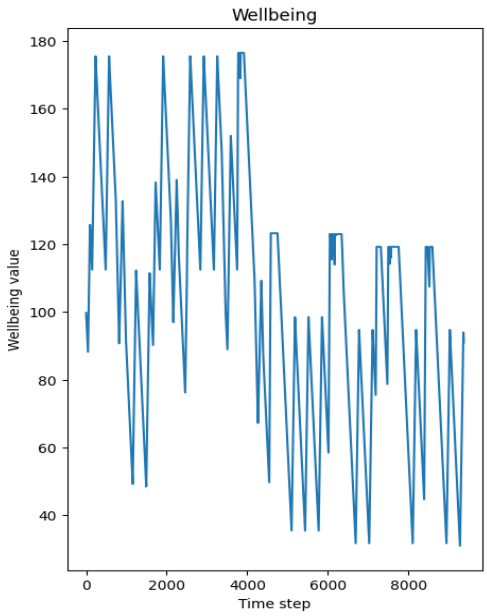


4. Complex Environment run number 4

```
Vitality = 0.5105791058297159
Vitality to the nearest two decimals = 0.51
Survival Time = 1 (never died)
```

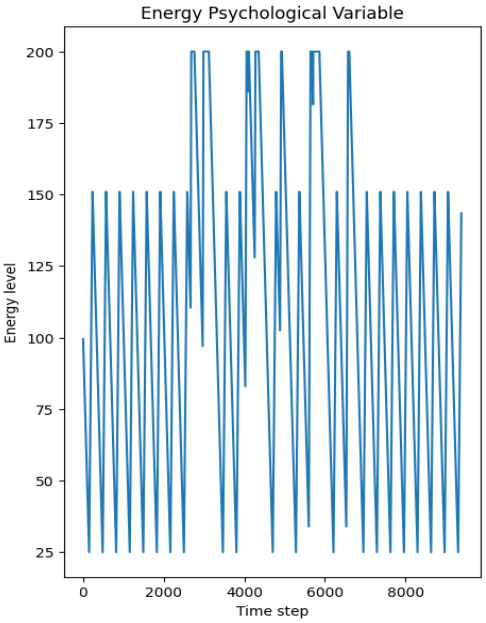


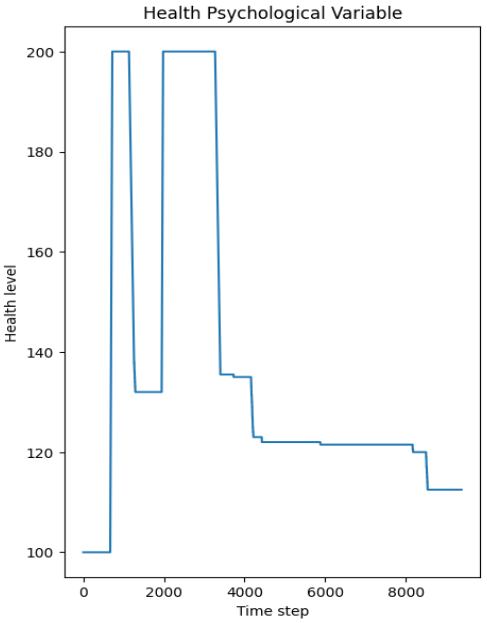


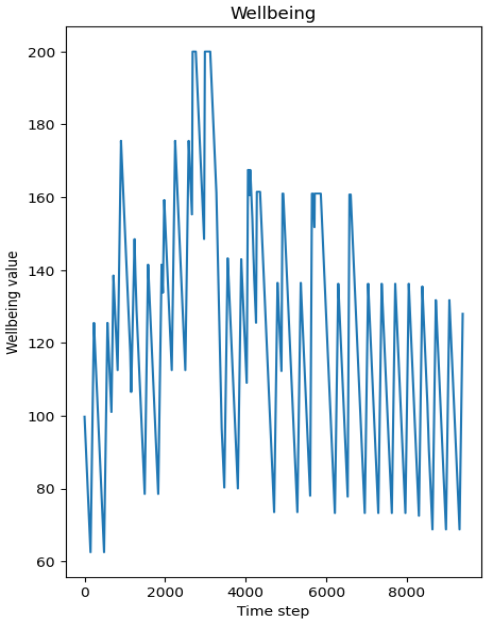


5. Complex Environment run number 5

```
Vitality = 0.6035621071694893
Vitality to the nearest two decimals = 0.6
Survival Time = 1 (never died)
```







As can be seen in the above graphs, the robot tends to have more energy level spikes reaching to maximum energy level in the basic environment and fewer energy spikes in complex environments. However, the biggest noticeable change is in the health psychological variable graphs, which shows clearly that the robot spends most of the run time in the basic environment with a maximum health value reaching the peak and the opposite in the complex environment runtimes, as it is noticed that the robot spends most of the run time with low health value.
Both the psychological variable graphs are clearly reflected in the well-being graph, which can be noticed from the steep drops found in the well-being graphs. It is noticed that in the basic environment the well-being value is relatively higher with less frequent and less steep drops, however in the complex environment well-being value is relatively lower with more frequent and steeper drops.
The survival time of the robot is 1 on all runs in both environments meaning that it didn't die at all times. The vitality calculated for each run reflects the condition of the robot relative to its psychological variables on the whole run. It was clearly shown that the robot's vitality is better in the basic environment with the average of all the runs evaluating 0.69 can also mean 69% vitality. On the other hand, the average robot's vitality of all the runs in the complex environment evaluates to 0.54 which can also mean 54% vitality.

Demonstration Videos

Firstly, in the demonstration video for the robot in the basic arena, it is noticed that the robot sometimes risks going into the red patches when at full health, seeking energy resources which are also demonstrated in the graphs of the quantitative analysis by medium drops in the health psychological graphs. It was also noticed that in the demonstration video the robot can sometimes ignore repair stations and prefer energy resources as a result of the domination of the fatigue motivation. As mentioned before in the qualitative analysis, the robot tends to execute the resting behavior in red patches when at full health and due to the absence of fear motivation which leads to the activation of the runaway behavior once resting is done. Furthermore, this is represented in the graphs of the quantitative analysis by sharp drops going under the initial starting health level. Moreover, the robot demonstrated its ability to avoid walls and red patches, especially at low health. Resting behavior happens frequently which is clearly represented in the graphs by a sudden increase till the energy level evaluates to 150 which is the optimum energy level and energy increases beyond the optimum level due to consuming an energy resource which was demonstrated in the basic environment video. Another demonstrated behavior in the video, was the forced movement of the robot when it's between a wall and a red patch leading it to move forward as a result of its fear motivation. The robot demonstrated that it covers most of the map while roaming due to absence of obstacles.

Secondly, in the demonstration of the complex arena, similar basic behaviors of the robot were demonstrated. The robot initiated the resting behavior on red patches just like in the basic

environment which also explains the sharp drops in the Health psychological graphs of the complex environment, however, due to the shortage of repair stations it can be noticed that the robot stays in low health level for more time than that in the basic arena, which was also seen in the complex environment graphs as robot health was more frequently represented as straight lines in low health values. In the video demonstration, the walls demonstrated how they prevent the robot from moving freely, blocking the robot from going to the center of the map, blocking the robot from reaching energy resources, and forcing the robot to move in certain directions especially when the robot is between a red patch and a wall. Furthermore, the robot was seen circling in the same area due to obstacles and red patches. Moreover, the robot was seen resting in the demonstration outside red patches at low health which is exactly why the robot avoids death at all runs, avoiding red patches at all costs when at low health. The robot was also demonstrating a behavior mentioned before in the qualitative analysis, which is moving in semi-circles around red patches. A certain behavior was also noticed at the same spot at the upper left wall between the red circle, environment wall and the obstacle wall as the robot would get redirected to face the same direction each time it approaches that spot, end up stepping on the red patch and resting than running away to hit the obstacle wall at minute 0:33 of the complex arena demonstration video. Moreover, the robot doesn't cover most of the map in one run. It was clearly seen in the demonstration that the robot spends most of its time avoiding red patches which are also reflected in the well-being graphs and vitality of the complex environment showing that well-being approaches more critical values and spends more time in lower levels. Furthermore, vitality is relatively lower with a percentage of 54%, unlike the basic environment which had a percentage of 69%.