Can a building have a heart: a durational slowly evolving AI artwork?

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Melbourne Connect

4800 Sensors + 1 Heart Sensor

150

The Heart is a site-responsive, slow Artificial Intelligence artwork to be lived with over decades. It reveals the pulse of a superorganism: the community visiting, living, and working in Melbourne Connect, a city-block size building, home of businesses, university departments, a kindergarten, accommodation, and a science museum. The Heart beats indefinitely for and with the life of the building and its community.

The Heart is connected to 4800 'Building Information Modelling' (BIM) sensors. These monitor CO2, humidity, room occupancy, temperature, movement, light, and more. The building adjusts the environment to create the optimum conditions for human comfort and safety. Normally, the automated work of building sensors and systems is dispersed and imperceptible. The Heart stages the building's 'sensations' in a way people can perceive and begin to empathise with. It does this by taking form in the foyer of Melbourne Connect as a 10-metre-tall volume of brass droppers, reconstituted brick fragments, and LEDs in the shape of a giant human heart.

The Heart "Goes to Sleep"

At 11:59 PM

Aggregate A Day's Worth of Real Sensors Data

~ 144 * 4800 aggregated readings per day

Normalize Data

Update The Heart Memory

The Heart Memory Span = M days

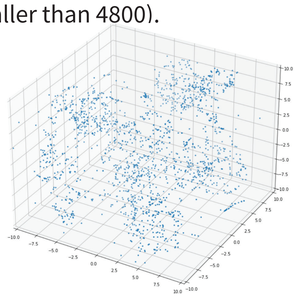
Yesterday → Today
Day (M-1) → Yesterday
Day (M-2) → Day (M-1)
Day 1 → Day 2
The Heart Memory only retians recent history
It forgets → Day 1

Online Machine Learning

The Heart Action Potential

We use Isomap [1] , a manifold learning algorithm to obtain non-linear embedding that reduces the sensors' data high-dimensional space (4800 dimensions, one for each sensor) to a lower-dimensional space (N dimensions, where N is much smaller than 4800).

Every day during the night, we **fit and transform** sensors' data from the last M days, to obtain a lower-dimensional representation of the data (the Manifold).
When N=3, the data can be visualised as 3D Manifold.
We call the manifold formed by real sensor data during the night **The Baseline Manifold.**



The Baseline Manifold

The Heart's Habituation

During the night, using sensors data from the last M days, we **continue** to train a Generative Adversarial Network (GAN) [2]

GAN is in the early stages of training

Generated data points (artifical sensors data) do not accurately reflect the sensor data distribution of building.

GAN has reached convergence

Generated data points (artificial sensors data) closely mirrors the actual sensor data distribution of the building

Visualisation

1- The artist can use the AI's output to manipulate visualisations and animations created by them and already running on the Heart. For example, the AI's output can control the pace, direction, and expansion of a specific animation.

2- The artist can set the lower dimensions (N) to 3, enabling the AI to output data points in 3D. This makes it possible to push the formed manifolds directly into The Heart in a coordinate system centred in the centre of the heart node.

3- The artist can choose to display the baseline manifold in the morning as the first thing the heart does in the day. This display reflects what was learned during the night.

4- The artist can enable or disable generating artificial sensor data during the day. This is useful during the early stages of training the GAN when the output is mostly noise.

5- During a hosted event such as a conference, when the sensor readings are unusually high, the new sensor readings will appear as outliers or separate clusters. The dynamic manifold will not align well with the baseline manifold.

6- Additionally, when the generative model is enabled, we can tell the GAN has reached a convergence when the dynamic manifold aligns well with the baseline manifold. This means that GAN is able to "fill in the gaps" and generate artificial sensors data that looks similar to real sensors data.

The Heart wakes up at sunrise

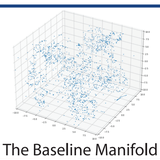
We get sensors readings every 10 to 15 mins

Temperature (Room 3201) | CO2 (R02) | Humidty R(M201) | ....

4800 Dimensions

Min 01 | 23,123,0,34,18,20,.....,280
No data
Min 15 | 16,87,0,50,33,250,.....,150

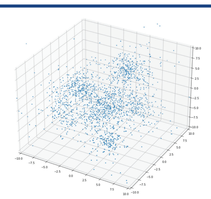
Normalize Data



The Baseline Manifold

GAN Generate → Isomap Transform → Real Sensor Data
GAN Generate → Isomap Transform → Artificial Sensor Data
GAN Generate → Isomap Transform → Artificial Sensor Data
Isomap Transform → Real Sensor Data

N<<4800 Dimensions



The Dynamic Manifold

During the day a Manifold is formed from real and artificial sensor data.
We call it **The Dynamic Manifold**

Evaluation

GAN is in the early stages of training

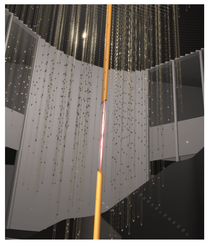
When the generated data points are transformed by the Isomap embedding and visualized, they do not align well with the manifold formed by the real sensor data.

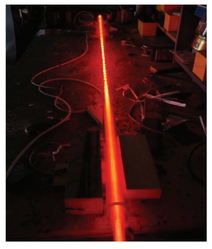
GAN has reached convergence

This convergence is reflected in the manifold visualization, where the artificial sensor data, after being transformed by the Isomap embedding, align closely with the manifold formed by the real sensor data.

The Heart Pulse

The Heart Pulse Algorithm imitates the way the human body regulates Mean Arterial Pressure (MAP). The algorithm responds to sensor readings from all rooms (analogous to 'the building's organs') in a manner similar to how the human body responds to changes in MAP, which is influenced by how much blood the organs need.
During events like hosted conferences, when sensor readings are unusually high due to increased occupancy, CO2 levels, among other factors, the algorithm reacts. Just as our heart rates increase during exercise to enhance the Cardiac Output and maintain a stable MAP, the algorithm increases the building's pulse rate.





The Heart Sensor

When visitors donate their heartbeats by touching the Heart Sensor for 10 seconds, they get an immediate visual pulsating effect that originates from the heart node and slowly spreads through the heart. Their heartbeats' data is also added as additional sensor reading to the data used to derive the Heart pulse and train the AI.

[1] Tenenbaum, J.B., De Silva, V. and Langford, J.C., 2000. A global geometric framework for nonlinear dimensionality reduction. Science, 290(5500), pp.2319-2323.[2] Goodfellow, I. et al., 2014. Generative adversarial nets. In Advances in neural information processing systems. pp. 2672–2680.