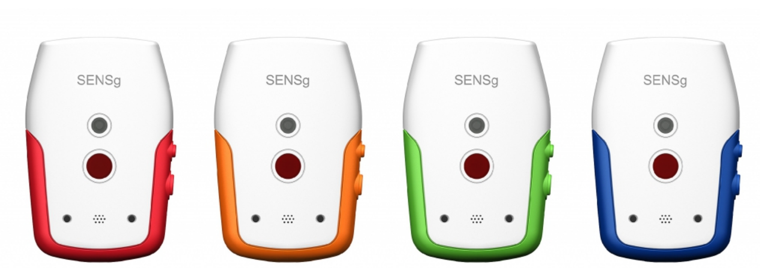
What is SENSg



The device, named "SENSg" (pronounced "SENSE-SG") measures and stores data on motion, temperature, humidity, atmospheric pressure, light intensity and sound pressure levels, which are correlated to the sensor's location. The device uses Wi-Fi signals to localise itself, and periodically uploads sensor data to a secured database if it is in range of a known access point. The sensor data is anonymous, and stored securely in the cloud.

The SENSg device was designed and developed by researchers from the Singapore University of Technology and Design (SUTD) as a "Laboratory on a Lanyard" to enable Singapore's National Science Experiment. It offers several unique and original features:

- Lowest cost in class: they are designed as the lowest-cost multi-functional sensor available so that a large number can be deployed throughout Singapore over a long period of experiments;
- Radio localisation: they use their Wi-Fi radios not only to move data from the device, but also to 'sniff' Wi-Fi

How to use SENSg

Download the instruction manual or refer to this list of Do's and Don'ts.

Do…

SENSg

About SENSg

hotspots in order to determine their location; and
- Rapid-prototyping: they use an open compilation toolchain to allow students to learn how to code, experiment, sense, and build their own applications on the SENSg devices.

The SUTD team worked hard to create this unique, Singaporean technology, and hope that you enjoy experimenting with the devices in the National Experiment and beyond!

What kinds of data can SENSg collect?

Relative Humidity & Ambient Temperature

Don't...

Electronic humidity sensors can be broadly divided into three categories: capacitive, resistive and thermal conductivity. The SENSg devices contain capacitive humidity sensors. The accuracy of the relative humidity reading is strongly dependant on temperature, since temperature is in the formula used to calculate its value. As such, we have designed the SENSg devices with multiple perforations to increase ventilation, and mounted the sensor in a way to minimise heat transfer from other electronic sensors.

For more information, you can read: https://en.wikipedia.org/wiki/Relative_humidity

Pressure

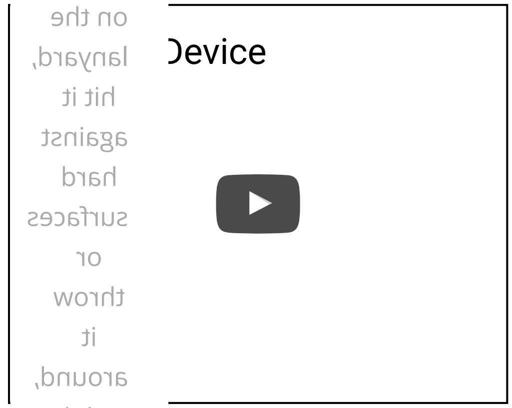
The SENSg device's pressure sensor consists of a piezo-resistive sensor. Change in pressure results in a change in electrical resistivity of the sensor, and altering current or voltage readout which is correlated to pressure readings. The measured pressure allows for estimation of the altitude, i.e. the height above sea level you are at.

For more information, you can read: https://en.wikipedia.org/wiki/Atmospheric_pressure

Temperature

The SENSg device contains an infrared (IR) thermometer that provides non-contact temperature sensing. It measures the temperature of an object by sensing the infrared radiation emitted by the object (which is given by Planck's law) and converting the voltage generated to a digital reading of the temperature. The lens covering the IR thermometer sensor requires uses special materials to minimise reflection and absorption by the lens material.

For more information, you can read: http://www.sensorsmag.com/sensors-mag/demystifying-thermopile-ir-temp-sensors-13157



Sound

The microphone in the SENSg device converts acoustic (sound) pressure waves to electrical signals, and provides the Sound Pressure Level readings in decibels. Typical ambient noise in Singapore measured at night is around 55 decibels (dB), reaching up to around 80 dB in the day. The SENSg devices use special capacitive micro electromechanical systems (MEMS) microphones to measure sound pressure level for measuring city noise.

For more information, you can read: https://en.wikipedia.org/wiki/Microphone#MEMS_microphon

Light

The SENSg devices contain a photodiode to measure light. The light which shines on the photodiode is first passed through a specially designed filter to ensure that reads light in the visible range similar to what is perceived by the human eye, and generates a small amount of current which is used to measure light. Similar to the IR thermometer sensor, the light sensor must to be mounted behind a clear lens to ensure accurate light intensity measurements. Photodiodes are often used in applications such as street lighting control, back-light calibration, etc where light must be adjusted according to how humans perceive light.

For more information, you can read: https://en.wikipedia.org/wiki/Photodiode

Inertial Measurement

The SENSg device contains a MEMS Inertial Measurement Unit (IMU) which combines a 3-axis accelerometer, 3-axis gyroscope and 3-axis magnetometer in the same chip. This chip also comes with a built-in pedometer function to fuse sensor data and provide the step count reading.

The accelerometer measures acceleration forces; these forces may be static (gravitational force) or dynamic such as those generated through motion. A MEMS accelerometer can be thought of as a tiny vibrating bridge, where the changes in vibration are used to estimate force.

A gyroscope is a spinning wheel or disc in which the axis of rotation is free to assume any orientation. A MEMS accelerometer uses a tiny, specially designed vibrating structure which measures angular velocity about the X-, Y- and Z- Axes, also known as the roll-, pitch- and yaw- axes respectively.

The magnetometer detects the earth's magnetic field and is used to compensate for orientation drift.

For more information, you can read: https://en.wikipedia.org/wiki/Inertial_measurement_unit

Step Count

Counting steps is most often performed by measuring the magnitude of acceleration along a particular axis (x,y,or z). If the acceleration is greater than a specific amount, a step is registered. Analog measurement devices use simple technologies such as a weight attached to a spring which is tuned to bounce against a switch if a step is taken. Popular devices such as the 'FitBit' which exist for measuring personal activity use MEMS accelerometers such as the one in the SENSg device. By watching the acceleration cross thresholds according to some rules, accurate step counting can be performed.

For more details on the types of algorithms which can be applied, you can read: http://www.analog.com/library/analogdialogue/archives/44-06/pedometer.html

Indoor/Outdoor Time

Whether a student is indoors or outdoors is defined by:

- Air conditioned indoor spaces versus open air spaces e.g. offices, malls and hospitals

- Covered indoor spaces (roved, with windows doors and ventilation but no air conditioning) versus open air spaces e.g. classrooms with ceiling fans, MRT stations and underground parking garages

The algorithms which we are developing use the differences in relative humidity and light between indoor and outdoor spaces in the different cases to differentiate between them. Of course, time of the day is taking into consideration when using the light algorithm.

Travel Pattern

A student's mode of transportation is determined by:

- Whether a person is on foot, in a motorised mode of transport, or on a train
- Whether a person is in a motorised form of mass transit or a light-duty vehicle

All of the machine learning should happen on the device, since we are limited in terms of how much data we can send back to our more powerful webservers. This is a big challenge, and is solved with the help of decision trees which have been designed based on data collected across a set of travel modes before the National Experiment. Nevertheless, it would be great if students can log into this NSE web portal and check if our artificial intelligence got it right – you will have a chance to tell us if we guessed your travel mode correctly.