

Freedom in Spectroscopy

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Overview

What is Spectroscopy ?

- Fundas :)

- Spectrum

- Kinds

What is a Spectrophotometer ?

- Constitutes ...

- In simple terms ...

What is the Necessity ?

- Ecology

- Space

- Medicine

Why not make it Free ?

- How can one Participate ?

Making One !

- Know to Start

- Know the Limits

What can be done with it ?

- Ask: What I can do ?

- Ask: What We can do ?

Dreams !

Any Values ?

Attempts

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This document represents mostly my thoughts, research, experiences and references
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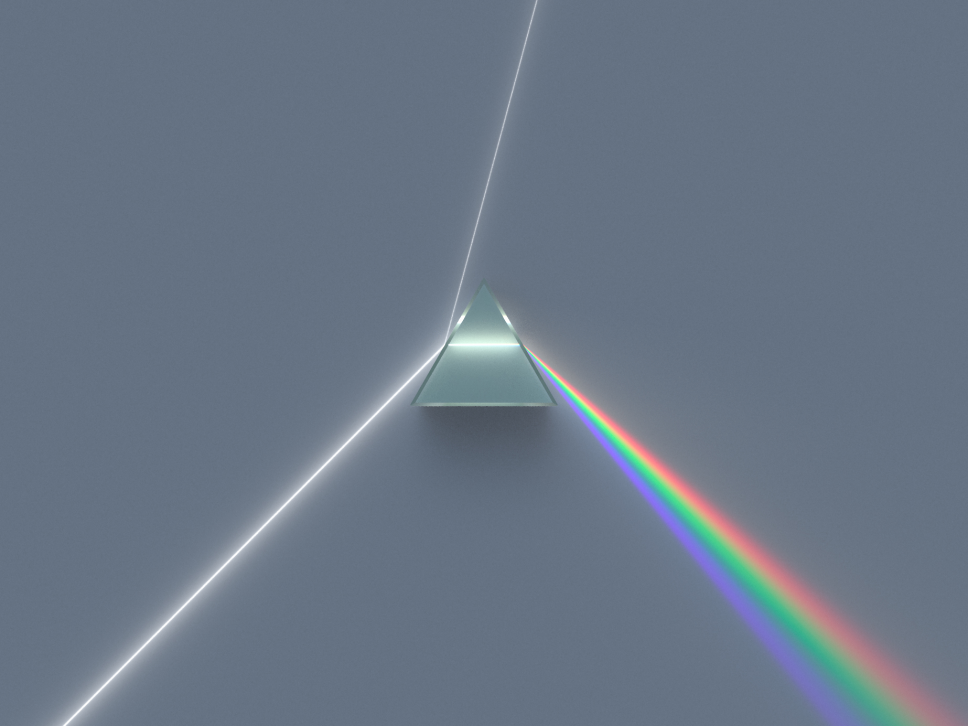
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Let's Start ...

if you want to find the secrets of the universe, think in terms of
energy, frequency and vibration

- Nikola Tesla



Why Spectroscopy ?

For communication or exploration or analysis or identification or for fun :)

- ▶ Smell
- ▶ Taste
- ▶ Texture
- ▶ Shape
- ▶ Size
- ▶ Mass
- ▶ Structure
- ▶ Composition

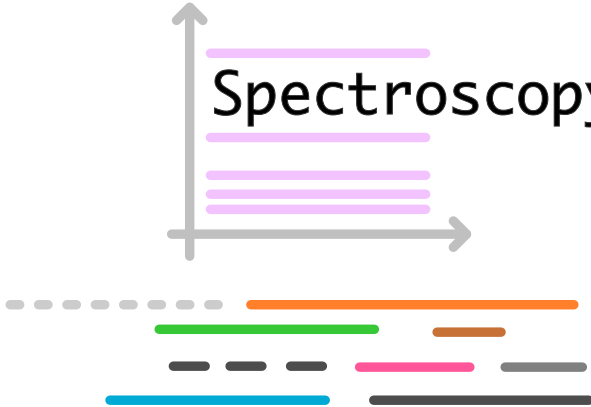
Which one is the most fundamental that can help derive other measurements ?
Or can one be mixed with other ones to make a most accurate, precise, reliable
– possibly true or factual measurements possible ?

Think ! Think ! Think :)

$$E=h\nu$$



Spectroscopy



$$c=\lambda\nu$$

What is Spectroscopy ?

Study of Interaction between Matter & Electromagnetic Radiation

- - - - -

Measurement of Radiation Intensity as a function of Wavelength

Resonance

- - - - -

Resonant Frequency

- - - - -

Spectrum \equiv Collection of Resonant Frequencies

Electromagnetic spectrum through XKCD's view

THE ELECTROMAGNETIC SPECTRUM

THESE WAVES TRAVEL THROUGH THE ELECTROMAGNETIC FIELD. THEY WERE FORMERLY CARRIED BY THE AETHER, WHICH WAS DECOMMISSIONED IN 1897 DUE TO BUDGET CUTS.

ABSORPTION SPECTRA:

HYDROGEN:



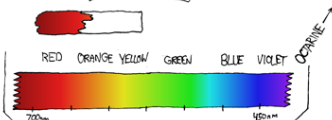
HELIUM:



DEPENDS@:



TAMPAX®:



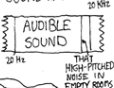
VISIBLE LIGHT

OTHER WAVES:

SLINKY WAVES



SOUND WAVES



THE WAVE



SHOUTING CAR DEALERSHIP COMMERCIALS

CIA (SECRET)

HAM RADIO

KOSHER RADIO

SPACE RAYS
CONTROLLING
STEVE BALLMER

99.3 "THE FOX"
101.5 "THE BADGER"
106.3 "THE FROSTENED SQUIRREL"

24/7 NPR
PIECE DRIVES

AM (US)

VHF

UHF

CELL PHONE
CANCER RAYS

ALIENS
SETI

GRAVITY

WIFI
BRAIN WAVES

SULAWESI

SUPERMAN'S
HEAT VISION

IRON
BLACK'S
HEAT VISION

SUNLIGHT

MAIN
DEATH
STAR LASER

POTATO

BLOGORAYS

MAIL-
ORDER
X-RAY GLASSES

SINISTER
GOOGLE
PROJECTS

CENSORED UNDER PATRIST ACT

POWER & TELEPHONE

RADIO & TV

MICROWAVES

TOASTERS

IR

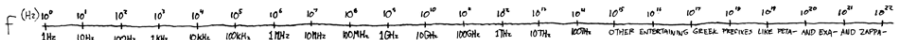
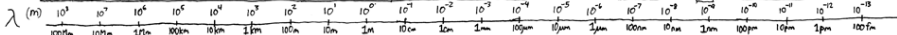
VISIBLE LIGHT

UV
VISIBLE DARK

MILLER LIGHT

X-RAYS

GAMMA/COSMIC RAYS



It is the fundamental part of Nature



Air, Water, Soil

Depends on:

- ▶ *What part of Spectrum (Energy) one is looking at ?*

- ▶ Radio - VLF, LF, HF, VHF, UHF, MW
- ▶ Infrared - Thermal, FIR, MIR, NIR
- ▶ Visible
- ▶ Ultraviolet
- ▶ Ionizing - X rays, Gamma rays
- ▶ ...

- ▶ *What Excitation Energy involved ?*

- ▶ Translational
- ▶ Rotational
- ▶ Vibrational
- ▶ Electronic
- ▶ ...

Depends on:

► *What Interaction theory used for study ?*

- Emission
- Absorption
- Atomic Mass
- Molecular
- Infrared
- Raman
- Flourescence
- Impedance
- ...

Types ...

Depends on:

- ▶ *How one sees & uses it ?*
 - ▶ For Communication
 - ▶ For Exploratory Analysis
 - ▶ For Testing
 - ▶ ...

- ▶ *What technology used for Measurement ?*
 - ▶ Fourier Transform
 - ▶ Acousto-Optics
 - ▶ Electro-Optics
 - ▶ Nuclear Magnetic Resonance
 - ▶ ...

Applications

Used primarily in:

- ▶ Material Identification
- ▶ Food Inspection (True Fingerprint Id.)
- ▶ Drug Inspection (True Fingerprint Id.)
- ▶ Remote Sensing
- ▶ Space Probes
- ▶ ...

Can be coupled with:

- ▶ Microscopy
- ▶ Telescopy
- ▶ Astronomy
- ▶ LIDAR
- ▶ Robotics
- ▶ ...

Spectrophotometer



What is a Spectrophotometer ?

An Instrument that:

- ▶ Helps study the ***Interaction*** between Energy and Matter.
- ▶ ***Measures*** Radiation Intensity during such ***Interaction***.
- ▶ ***Analyze*** collected Spectrum within the Bandwidth.
- ▶ ***Identify species*** of the material under test.

What does a Spectrophotometer Constitutes of ?

1



Excitation Source

2



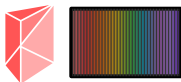
Sample Placement

3



Collimation

4



Dispersion or Diffraction

5.a



Electronic Detection

5.b



Manual Observation

6.a



Measured Spectrum

7



8



6.b

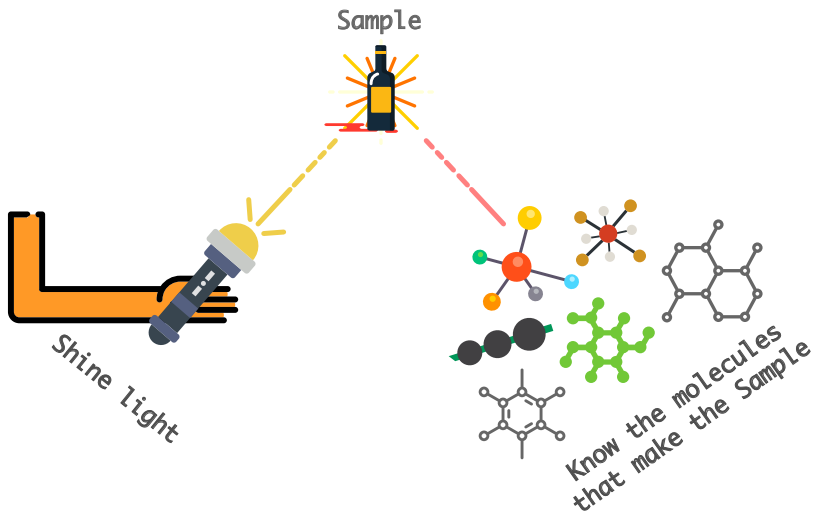


Observed Spectrum

Pal... ! can you make it Simple !...



Ok ! Le me Try 😊



So What ???



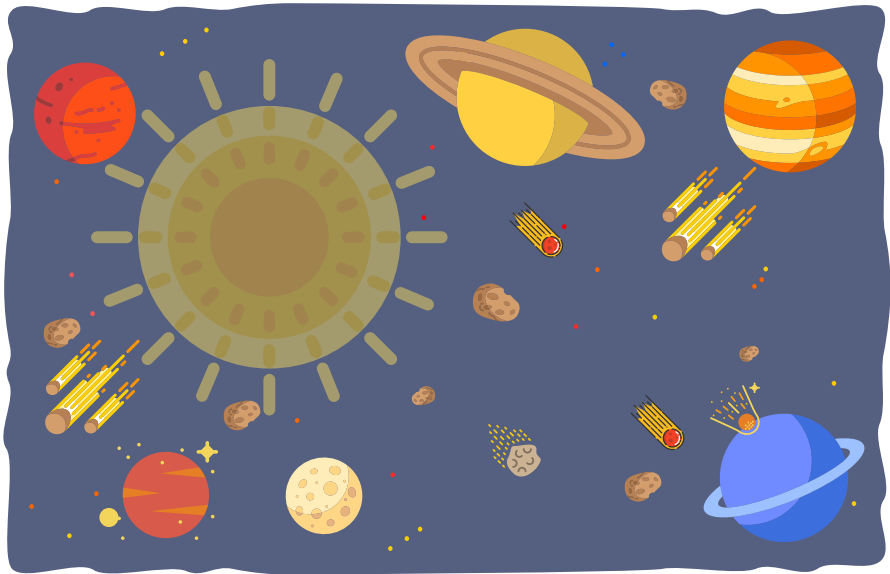
Necessity

We Humans always tend to damage Systems, learn from it & again attempt to repair it !

- ▶ Don't u want to know the truth ?
- ▶ Every instrument at some point of time is a DIY triumph of someone ! Its time to make it open !
- ▶ Is it not the right time to make Scientific Instruments Democratic ?
- ▶ Is it not the time to make Education more fun through Discovery ?
- ▶ Is it not the time to practice Collaboration based Peer Production (**CBPP**) principles ?
- ▶ I do want to know what is my food ? without believing the data provided by somebody else !
- ▶ Be the inspector yourself ! (**end to end inspection** is never before democratized)
- ▶ Now i can stamp my food with its true nutritional value, which others can verify !
- ▶ With **e2e inspection**, no need of "monitoring" establishments :p



Some of us interested to know what's in these ... TRULY ! & REALLY



Are you interested in knowing what's there & what they made of ?

[illegible]

Cool ! It's getting Interesting ...



Freeeeedom !



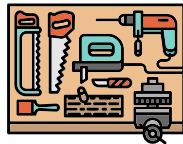
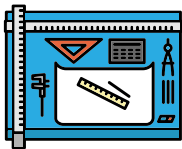
Freeing :)

- ▶ As open community with collaborative practice
- ▶ Using Free Software based CAD/CAE tool for design
- ▶ Using Free Hardware designs & tools to make
- ▶ Using Free Software OS, libraries to create firmware, software stacks
- ▶ Using Free Database stack
- ▶ Using Free Data Analysis tools (discipline specific)
- ▶ Using Free UX design stacks
- ▶ Using Distributed architecture for Sharing Data, Analytics

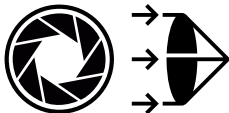
Participation

What kind of guys do we need for Co-operative + Collaborative participation ?

- ▶ Mechanical
- ▶ Optics
- ▶ Electrical
- ▶ Electronics
- ▶ Software
- ▶ Data Sharing & Distribution
- ▶ Chemoinformatics(Chemometrics)
- ▶ Bioinformatics
- ▶ Data Analytics
- ▶ Pattern Recognition & Matching
- ▶ Machine Learning



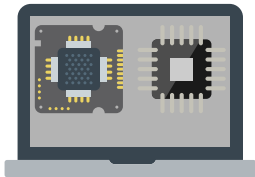
Mechanical - Design & Construction



Optical - Design & Construction



Electrical - Power conditioning



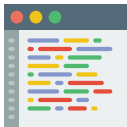
Electronics - Design, Fabrication



Chemoinformatics - Data Analysis
Pattern Matching
Machine Learning



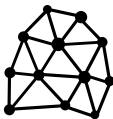
Bioinformatics - Data Analysis
Pattern Matching
Machine Learning



Software - Algo. Dev., UX Design



Data Analytics



Distributed - Data Sharing, Network Systems

Construction



Construction !

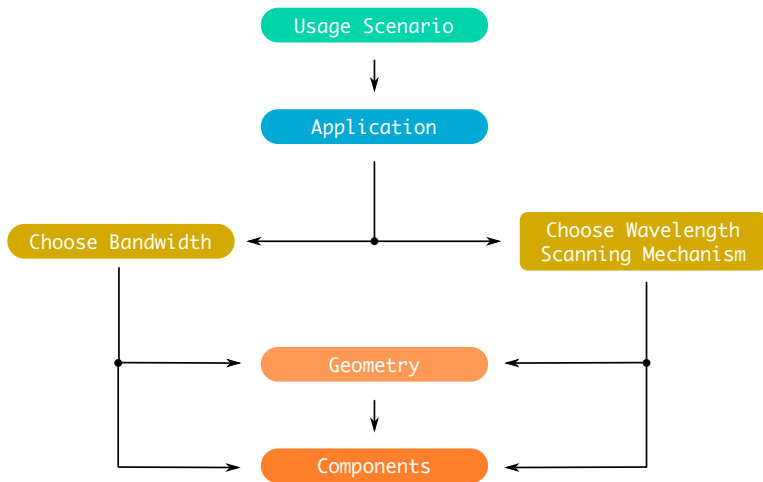
Construction depends on Architecture that deals with
Wavelength Selection in best possible way.

It contributes to:

- ▶ Selection of Components that influence the energy flow
- ▶ Geometry to guide the energy flow between the components
- ▶ Sensitivity & Resolution of the instrument
- ▶ Repeatability, Accuracy & Precision of the measurement
- ▶ Specify the Efficiency of the instrument

Sweet corner for Makers, Hardware hackers, Designers, Architects ... ! :)

Where to Start ?



Know the Limitations

When band changes, even ideas & thought process changes :)

- ▶ No single instrument can cover the entire Electromagnetic Spectrum
- ▶ It is practically hard to build a spectrophotometer to cover multiple bands
- ▶ For common man, the organics are very interesting to Explore, Learn & Use
- ▶ Most of the organics can be explored with UV, Visible, NIR, MIR, FIR bands
- ▶ Covering multiple bands may involve using different diffraction techniques
- ▶ Covering multiple bands, in single floor, may require multiple source & detectors
- ▶ Availability (or) Affordability of standard open spectra is a major problem
- ▶ Analysis Problem : Data analysis are specific to the bands, diverse

Don't get intimidated

Bandwidth

Spectral Bandwidth is the common factor of
Excitation Source, Diffracting element, & Detector

To Start : Find a bandwidth with :

- ▶ Band that covers most of the Organics
- ▶ Availability of lot of Standard/Known Spectra
- ▶ Optional : Consider (available + affordable) Source & Detector

Wavelength Selection Mechanism

With new materials, techniques, and research, new wavelength selection
(scanning or tuning) mechanisms are discovered & implemented

- ▶ Prism (Dispersion)
- ▶ Interferometer (Interference)
- ▶ Grating (Diffraction)
- ▶ Prism Grating Prism (Dispersion + Diffraction)
- ▶ Volume Phase Grating (Diffraction)
- ▶ Acousto-Optical Filter (Diffraction)
- ▶ Electro-Optical Filter (Diffraction)
- ▶ Digital Light Processing (Reflection + Diffraction)

Energy Source

Depending upon the bandwidth the selection of source varies.

- ▶ Look for long life time (understand how it works !)
- ▶ Check whether cooling increases life and efficiency
- ▶ Check whether reflectors improve optical output behavior
- ▶ Study its optical & spectral characteristics by comparing with:
color temp. / solar spectrum
- ▶ Confirm that its spectral characteristics matches chosen bandwidth
- ▶ Power requirements change drastically depending upon the source type
- ▶ Understanding its electrical behavior, helps design better power conditioner

From coolidge tube to magnetrons, from LED's to LASER's, from nichrome wires to halogen lamps – all are sources of electromagnetic energy at different frequencies.

Depending upon the bandwidth and application requirement the selection of detector varies.

- ▶ Look for low noise detector (understand how it works !)
- ▶ Check whether cooling reduces noise
- ▶ Most detectors require matched pre-amplifier unit
- ▶ Study its optical & spectral characteristics
- ▶ Confirm that its spectral characteristics matches chosen bandwidth

Structured conductors, Thermometers, Thermocouples, Photoconductive, Photoresistive, Photomultiplier, Semiconductors(Photodiodes, Phototransistors), CMOS arrays, CCD arrays, Scintillators etc.. are all commonly used different type of detectors – mostly influenced by the application.

What i planned?



What I did so far ?

Scavenging for packages

Purchase the "factory" food you are interested in

or

Free load your friends purchase

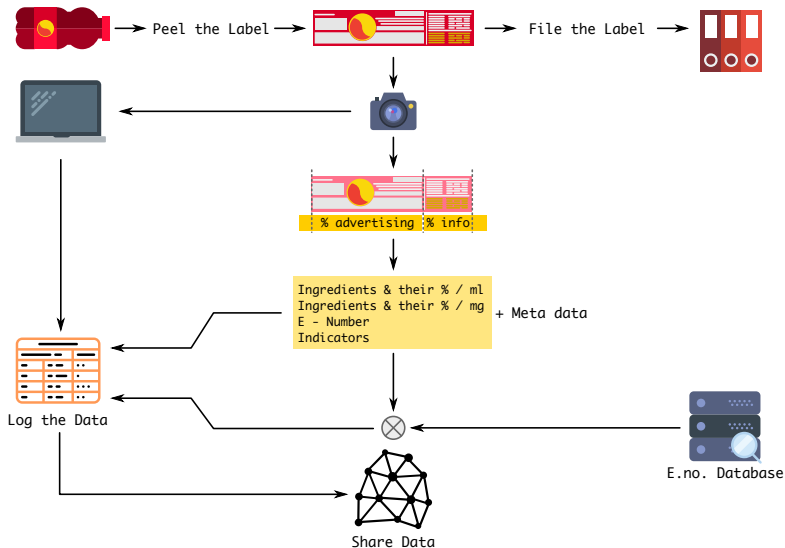
or

Hit the recycle shops

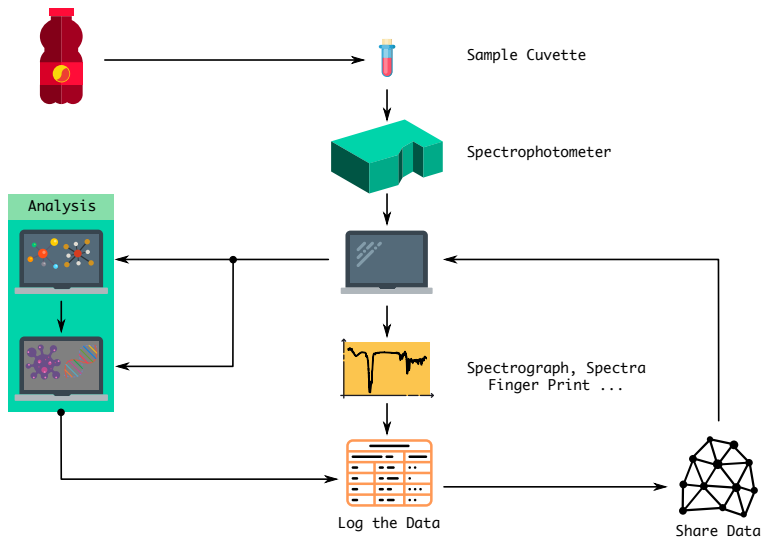
or

Hit the sidewalk

Collect Spatial Information



Collect Spectral Information



Sharing & Analysis

Mutually share data through distributed internet



Synchronize local DB



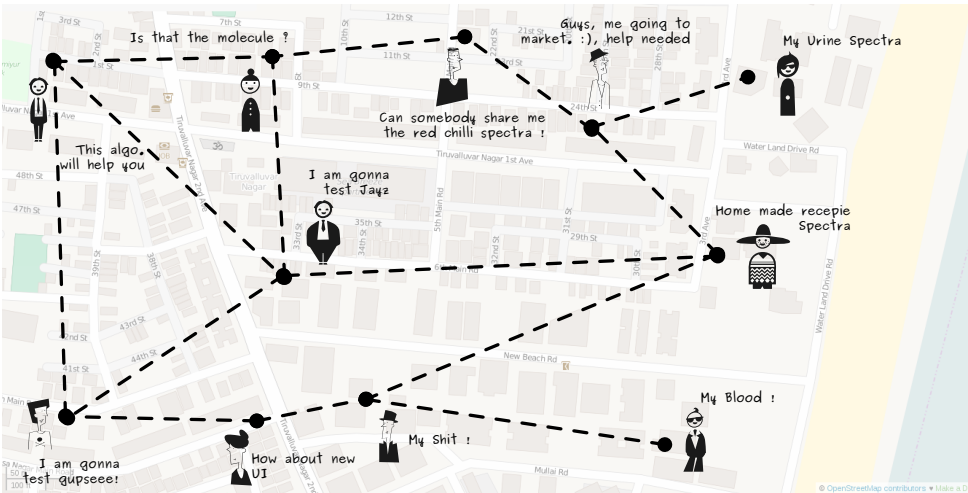
Run analysis with acquired Data



Share it back to the distributed internet

How about doing that Collectively ?





Apply Mesh & Geotransformation. This may be exaggerating.
But this is possible !

Dreaming

- ▶ Spectrophotometer along with Telescope, Microscope as an integral part of home
- ▶ With Mesh & SDR, let commons share the tools & data mutually
- ▶ Huge dictionary of TRUE spectra that continuously gets updated by commons
- ▶ With Distributed system available, working on mesh let commons to share analysis too
- ▶ Like e2e encryption, e2e inspection will become day to day necessity

Any Values ?

- ▶ Educational (Learning, Discovery & Doing, Science)
- ▶ Ecological (Food & Environment)
- ▶ Democratic (Distributed Participation in Sharing)
- ▶ Economic (Come onnnn think ! think ! think !)

Any other Attempts ?

Communities:

- ▶ OpenFoodFacts (So far only collaborates on Spatial info.)
- ▶ OpenWetWare - Urinome project
- ▶ Spectrduino - Satellite related
- ▶ Hackaday RamanPi by flatcat - Great guy like us
- ▶ Public Lab DIY spectrometer - Great community like us

Credits

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Thank you !