RRVP

A Research of Radar based on RSSI and Virtual PathLoss

1. Introduction

After the use of the IEEE 802.11 protocol there was a need to create RSSI-based radars, leading to several researches. Normally a radar uses *Time of Transmission* (*ToT*) methods like *ToA*, except for those devices that do not have software to use these systems, which is why RSSI-based radars have been developed for the 802.11 protocol.

RRVP was born from research on RSSI-based radar, adding virtual decibel path loss, therefore without compromising the result with signal loss caused by a concrete wall for example.

2. Use and info collection

RRVP is based on the first *Friis* equation and returns the distance in meters in a radius without specifying the direction (for Omni-Directional antennas). The meters are calculated by virtual pathloss and then by a *Friis*-based equation. Unlike all other radars, the calculation can be done simply without the use of special devices.

If you don't have all the information, just use average values, this applies to everything except the frequency and the dBm received which must necessarily be precise. The average of these topics may change from country to country due to the limits established by law.

Information	Average value
RXAntennaDBI	3
TXAntennaDBI	3
TXPowerDBM	20.5

3. Radar comparison

According to tests, RRVP has approximately 70% correct results in radiolocalization with an oscillation of approximately 2 meters, which is an excellent result considering the tests of other radars with error rates even over 85%.

System	Localization algorithm	Precision	Localization parameter
RRVP	Friis, Virtual Pathloss	30% error of approx. 2m in small environment, 50% error over approx. 150m	RSSI
RADAR	KNN, Viterbi-like algorithm	50% and 90% error of 2.5 and 5.9 m, respectively	RSSI
Horus	Probabilistic method	90% error of 2.1 m	RSSI
ILWP	EZ localization, genetic algorithm	A median localization error of 2 and 7 m, respectively, in a small building and a large building	RSSI
SpinLoc	Human rotation	Median localization error of 5 m	RSSI

Info taken from https://journals.sagepub.com/doi/10.1177/1550147717747858

4. Calculation

To calculate the distance in meters, you must first find the approximate decibel PathLoss with this calculation:

If frequency in 2.4 Ghz range:

$$\text{PathLoss} = 0.65 \cdot |ReceivedDBM| - 12$$

If frequency in 5 Ghz range:

$$PathLoss = 0.5555555555555556 \cdot |ReceivedDBM| - 8.222222222222221$$

The equation changes based on the Ghz, in fact the 5 Ghz react to pathloss differently. The higher the frequency tends to be, the less the pathloss will affect the final result. It’s important to know that these 2 formulas were created by tests after tests, there is no precise reason.

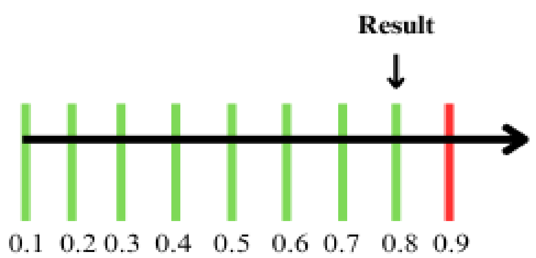
The fewer *ReceivedDBM* there are, the higher the pathloss will be, so it is recommended to use a small environment.

Now we can calculate the approximate distance in meters on a radius:

$$10 \cdot \log_{10}\left(\frac{RXAntennaDBI \cdot TXAntennaDBI \cdot TXPowerDBM \cdot c^2}{(4\pi \cdot HzFrequency \cdot m)^2}\right) < ReceivedDBM - PathLoss$$

M = meters, C = light speed

The *m* value must be increased until the equation is false, as soon as it is the approximate result of the meters is the penultimate *m* value.



For example, if we solve the equation by putting 0.8 meters (which turns out to be true) and 0.9 meters (which turns out to be false), the calculated meters will be 0.8 meters.

5. Code example

```
double numerator = rxAntennaDBI * txAntennaDBI * txPowerDBM * pow(299792458, 2);
double denominator = 4 * PI * HzFrequency;
double meters = 0.1;
while (1) {
    double approxDBM = 10 * log10(numerator / pow(semiDenominator * meters, 2)
    if approxDBM < (ReceivedDBM - PathLoss) {
        return meters;
    }
    meters += 0.1;
```

6. Conclusions

RRVP was designed especially for indoor localization, anonymously and without the use of special or sophisticated equipment. To use it best it is recommended to use Gapcast, an analysis and injection software where by adding the '-radar' parameter, you can read the approximate distance meters.

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