RRVP

A Research of Radar based on RSSI and Virtual PathLoss

1. Abstract

In environments where traditional radar usage is restricted by physical obstacles or lack of specialized hardware, the utilization of RSSI-based radar (Received Signal Strength Indicator) presents a promising solution. This study introduces RRVP, an innovative radar leveraging the combination of RSSI (Received Signal Strength Indicator) and Virtual PathLoss mainly for indoor localization.

2. Introduction

Following the widespread use of the IEEE 802.11 protocol, there arose a necessity for RSSI-based radars (Received Signal Strength Indicator), leading to various research endeavors. Typically, radars utilize Time of Transmission (ToT) methods like ToA and multilateration. RRVP emerged from research on RSSI-based radar (Received Signal Strength Indicator), incorporating virtual decibel path loss to mitigate signal degradation, such as that caused by physical obstructions like concrete walls.

3. How works

RRVP determines the distance in meters, especially suitable for omnidirectional antennas. The distance is calculated using virtual path loss and the first Friis-like equation. The peculiarity of RRVP is precisely that of the use of locating devices without the need for special equipment or particular systems, therefore it only requires knowledge of some necessary information, such as the specifications of the antennas and the output power (of both the receiver and the transmitter).

4. Radar comparison

Through a series of systematic tests, it was found that RRVP has relatively low error skew compared to its conceptual system. Error analysis was conducted by comparing the predicted values with those actually observed (distance). It was found that the discrepancy between prediction and reality remains within 30% for the first 10 meters, while between 10 and 25 meters remains within 50%, reaching a maximum of approximately 70% from 25 to 40 meters. Considering that these percentages do not represent the errors themselves, but rather the difference between the predicted and observed values, the error threshold is very low. It is noteworthy that there is no need for the use of sophisticated or specific equipment for the RRVP system, nor the need for a directional antenna, an omnidirectional antenna being sufficient.

If we compare some radars based on RSSI (Received Signal Strength Indicator) signals, we can observe that some systems have an error threshold that exceeds 6 meters, with a frequency that can even reach 90%. In contrast, in the worst case for the RRVP system, the maximum difference for the first 10 meters is approximately 30%, equivalent to 3 meters. This disparity highlights the greater precision and reliability of the RRVP system compared to radars based on RSSI signals, especially in the first few meters of range.

For example, let's compare such systems with RRVP:

System	*Localization algorithm*	*Precision*	*Localization parameter*
RRVP	Friis-like, Virtual Pathloss	30% max diff. within 10 meters, 50% max diff. within 10-25 meters, 70% max diff. within 25-40 meters	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

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It is important to keep in mind that all radars, including the RRVP system, can be affected by external interference or weather events, etc, which could cause a fluctuation in the final results and in some cases compromise their accuracy.

5. Virtual PathLoss

Virtual PathLoss is critical to evaluating potential signal loss. Path loss represents the attenuation of the RF signal between the transmitter and receiver. Its accurate determination is essential to obtain reliable results. It is worth underlining that the result obtained is virtual and represents an approximation, not a precise measurement but which is very close.

In initial research into calculating virtual pathloss, an equation was developed that averaged the presence of concrete walls in relation to distance. This approach, although correct in many contexts, presented significant discrepancies in results when applied at close distances without the presence of physical obstacles. In such situations, a deviation of more than 80% from the expected value was frequently found.

In order to improve the reliability of the Virtual PathLoss calculation, the equation was subsequently revised. The main change was the introduction of a dynamic consideration of signal loss based on distance. In particular, it was observed that for the first distances, within the first 0.5/1 meter or with a signal higher than -8 dBm, the signal power is generally high enough to not require the application of Virtual PathLoss.

It is essential to underline that the incorrect application of Virtual PathLoss in the presence of signals with a sufficiently high-power index could lead to distorted and compromised results.

6. Calculation of Virtual PathLoss

The calculation of Virtual PathLoss reveals a significant dependence on the frequency of operation of wireless communication systems. Below are presented proportional calculations relating to the variations of the Virtual PathLoss in relation to the different frequencies.

- Equation for 2.4 Ghz:

$$\frac{13}{20}(-ReceivedDBM) - 12$$

- Equation for 5 Ghz:

$$\frac{1}{2}(-ReceivedDBM) - 8{,}22$$

7. Calculation of meters

To approximately calculate the distance in meters, an equation similar to the first Friis equation is used. It is important to note that when the value of *ReceivedDBM* is high enough, especially above -8 dBm, it is appropriate to set the Virtual PathLoss to 0 rather than calculate it.

The equation requires several parameters, including:

Constants	*Details*
RXAntDBI	Antenna gain of receiver.
TXAntDBI	Antenna gain of transmitter.
TXPowerDBM	Output power (dBm) of transmitter.
ReceivedDBM	RSSI Received from trasmitter.
VirtualPathLoss	Virtual PathLoss.
HzFrequency	Signal frequency in hertz.
m	Distance meters.

After having obtained these parameters, you can proceed to calculate the meters:

$$\frac{\sqrt{\frac{RXAntDBI \cdot TXAntDBI \cdot TXPowerDBM \cdot c^2}{\sqrt[10]{10^{ReceivedDBM+VirtualPathLoss}}}}}{4\pi \cdot HzFrequency} = m$$

8. Conclusion

In conclusion, research on RRVP, a radar system based on RSSI (Received Signal Strength Indicator) and Virtual PathLoss, highlights its potential for indoor localization, particularly in environments where traditional radar methods encounter limitations. By leveraging RSSI (Received Signal Strength Indicator) signals and incorporating virtual path loss calculations, RRVP offers a viable solution for determining distances without the need for specialized hardware or complex systems.

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