KATEDRA MATEMATIKY A TEORETICKEJ INFORMATIKY

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Time Discretization Impact on the Target Localization Precision

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Outline

- Ultra wideband (UWB) radars
- Localization of a point target behind a wall
- Snell's law application
- Static person localization
- Numerical investigation of time discretization impact on localization precision
- Precision dependence on the sampling frequency
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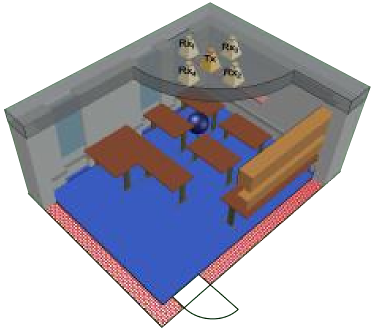
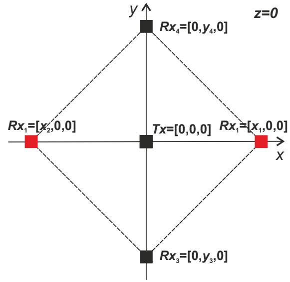
Ultra wideband (UWB) radars

The high bandwidth of ultra wideband (UWB) radars results in a high spatial resolution, typically a few cm. Thanks to good penetration through materials UWB radars can be very helpful, e.g., in the following situations: through-wall tracking of human beings during security operations, through-rubble localization of motionless persons following an emergency, e.g., earthquake or explosion, through-snow detection of people after an avalanche or through-dress security screening at airports for the detection of non-metal objects etc.

In the last decade, a great effort has been devoted to the research in the field of ultra-wide band (UWB) radar applications for person localization [1, 2].



(a)



(b)

(c)

(d)

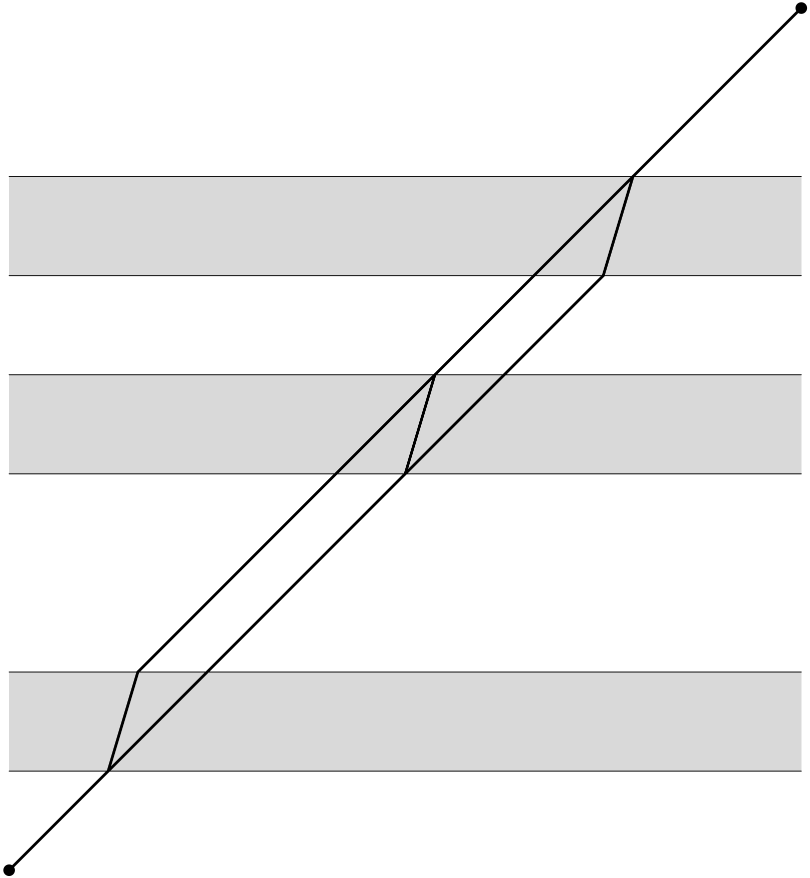
Localization of a target behind a wall

An algorithm for the localization of a point target behind a wall based on the information about times of a signal arrival (TOA) to the receivers has been presented at the 8th International Conference Numerical Methods and Applications in Borovets, Bulgaria in 2014 [3].

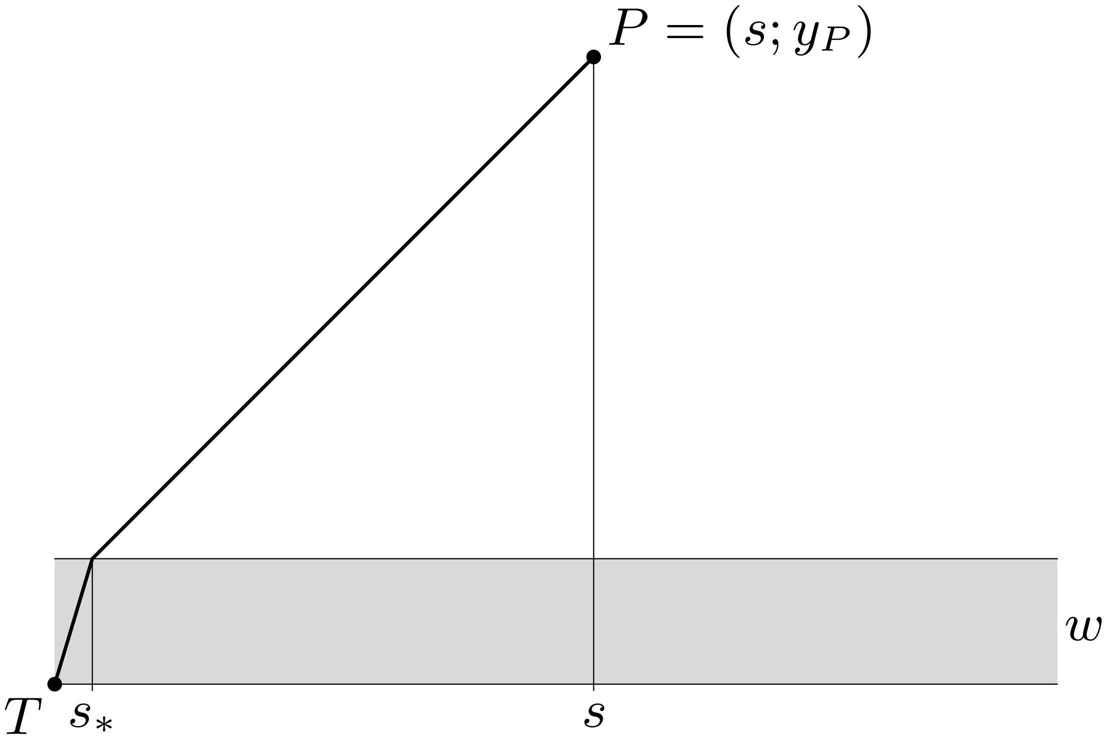
Under the assumption of 4 or more exact TOA values it is possible to determine not only the target position, but also the wall width (or the material relative permittivity).

Using some sampling frequency one get only TOA values rounded (at least) to the closest upper sample time. The impact of the time discretization on the target localization precision will be presented.

Snell's law application



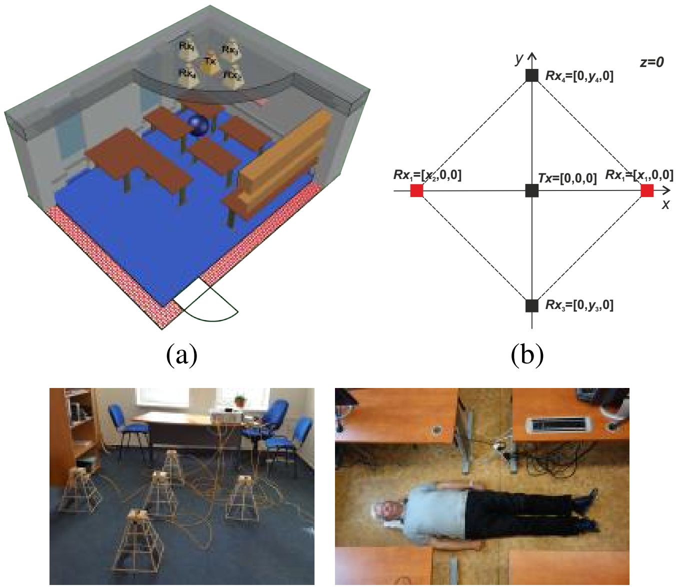
Snell's law application



$$\left[c_a^2 - c_w^2\right] \cdot s_*^4 - 2s\left[c_a^2 - c_w^2\right] \cdot s_*^3 +$$
$$+\left[c_a^2 y_P(y_p - 2w) + (c_a^2 - c_w^2)(s^2 + w^2)\right] \cdot s_*^2 + 2c_w^2 \cdot s \cdot w^2 \cdot s_* - c_w^2 \cdot w^2 \cdot s^2 = 0.$$

Static person localization

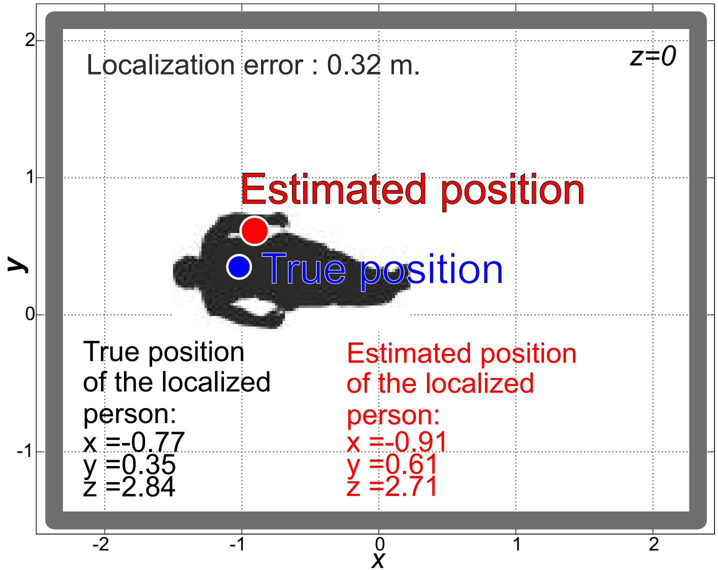
Note that the respiratory motion is usually the only visible form of a movement for a static motionless person.

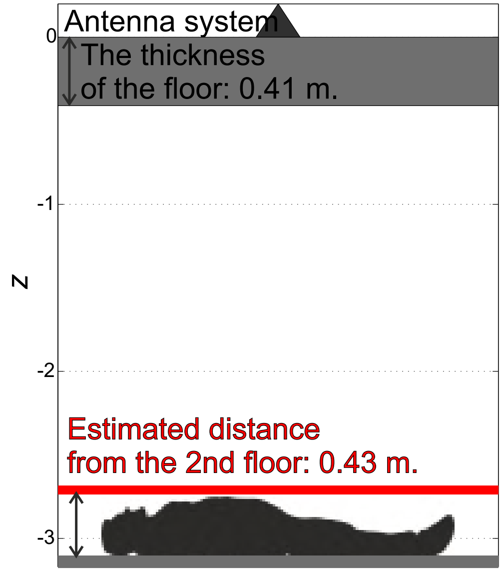


(a) (b)

(c) (d)

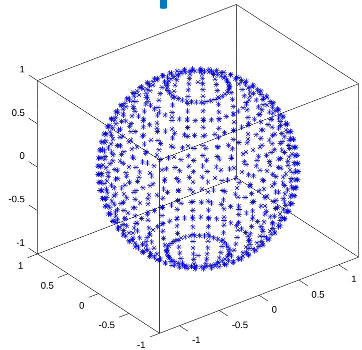
Static person localization

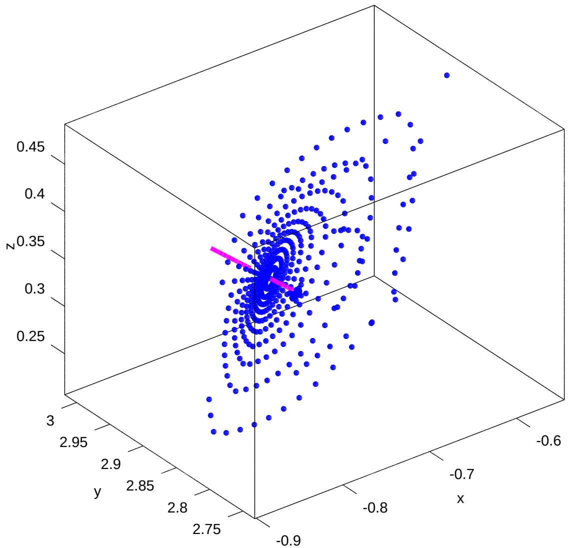




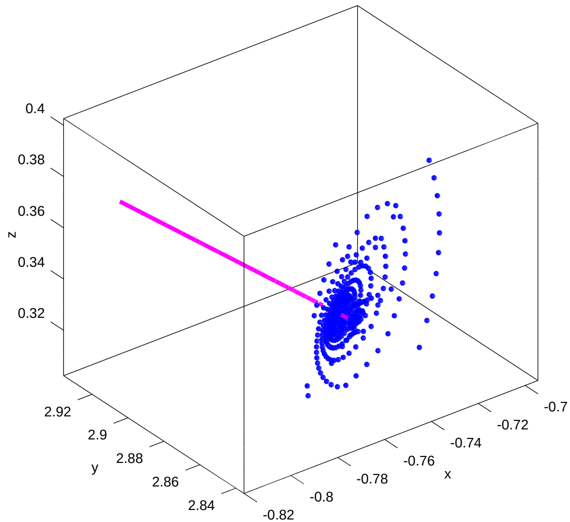
Relative permittivity 7.7 for reinforced concrete and receivers distance 0.8 m have been used.

Time quantization impact on localization precision



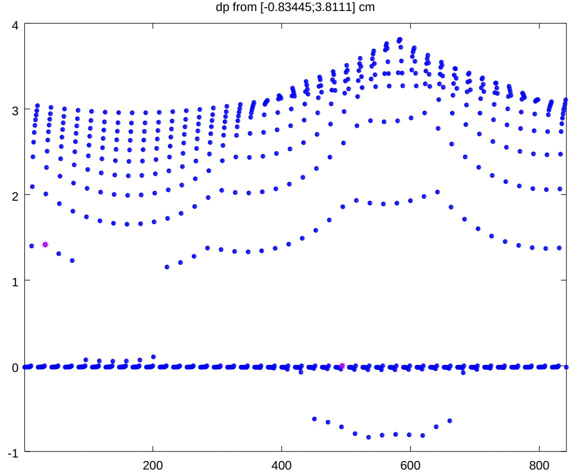


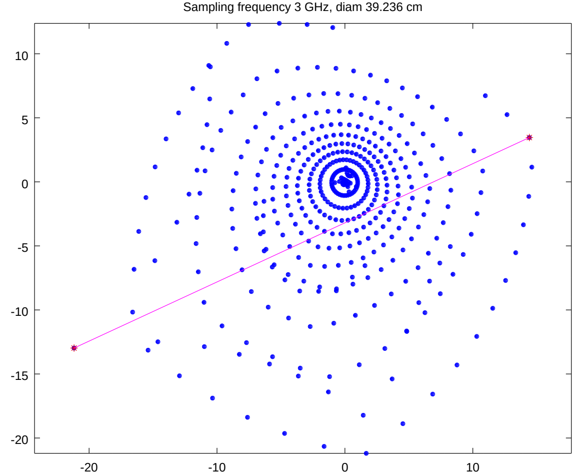
3GHz

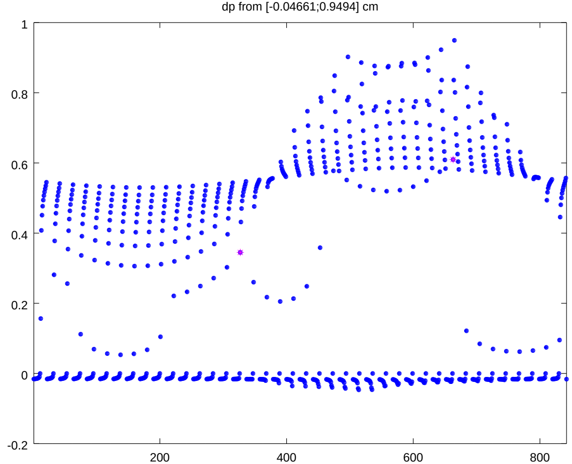


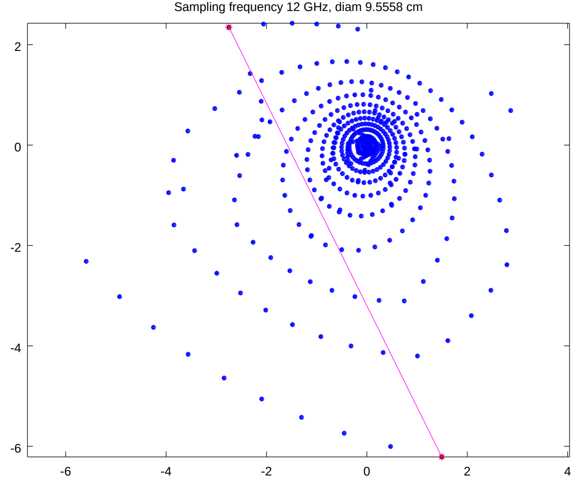
12GHz

$P = (-0.77; 2.84; 0.35)$ [m]

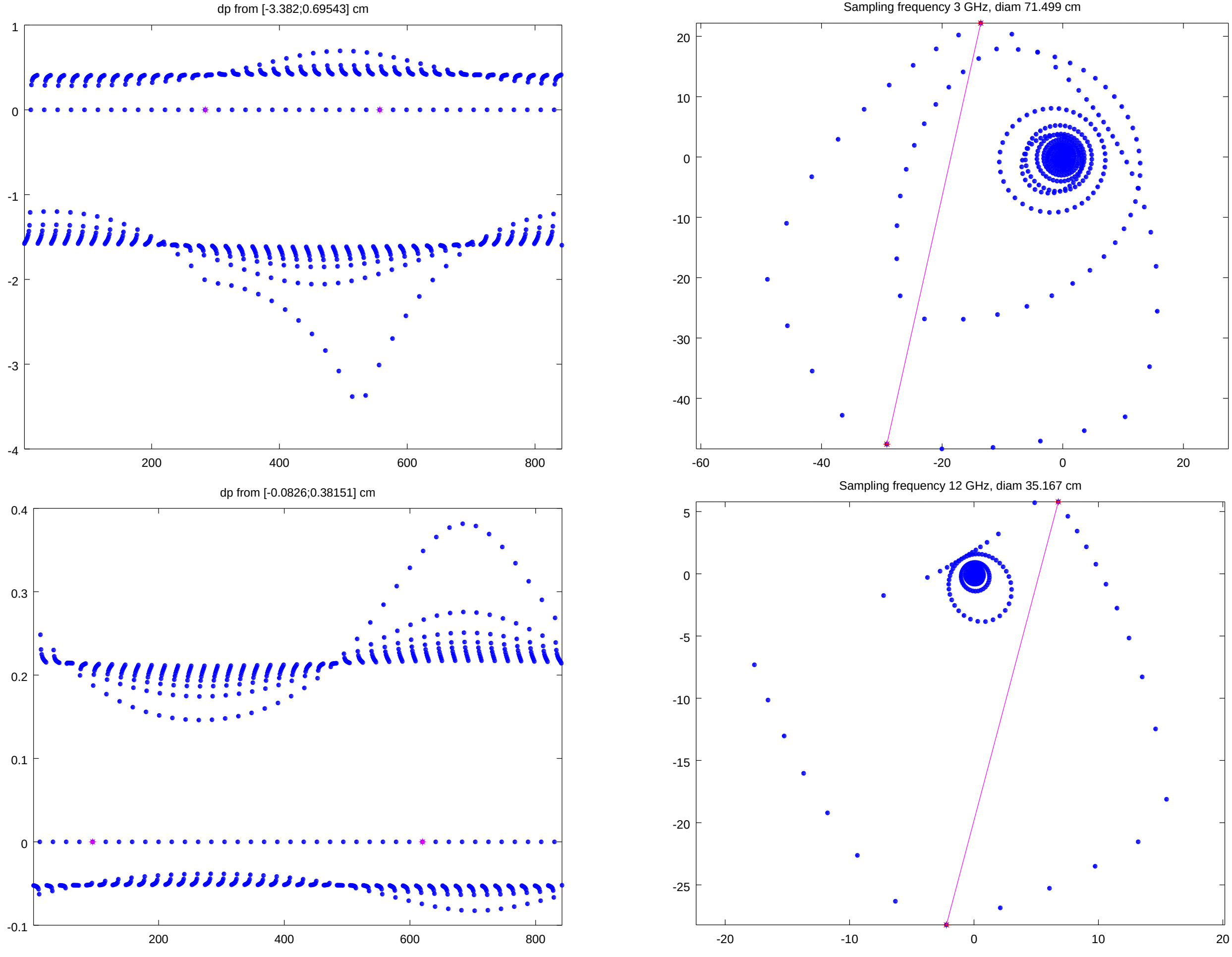




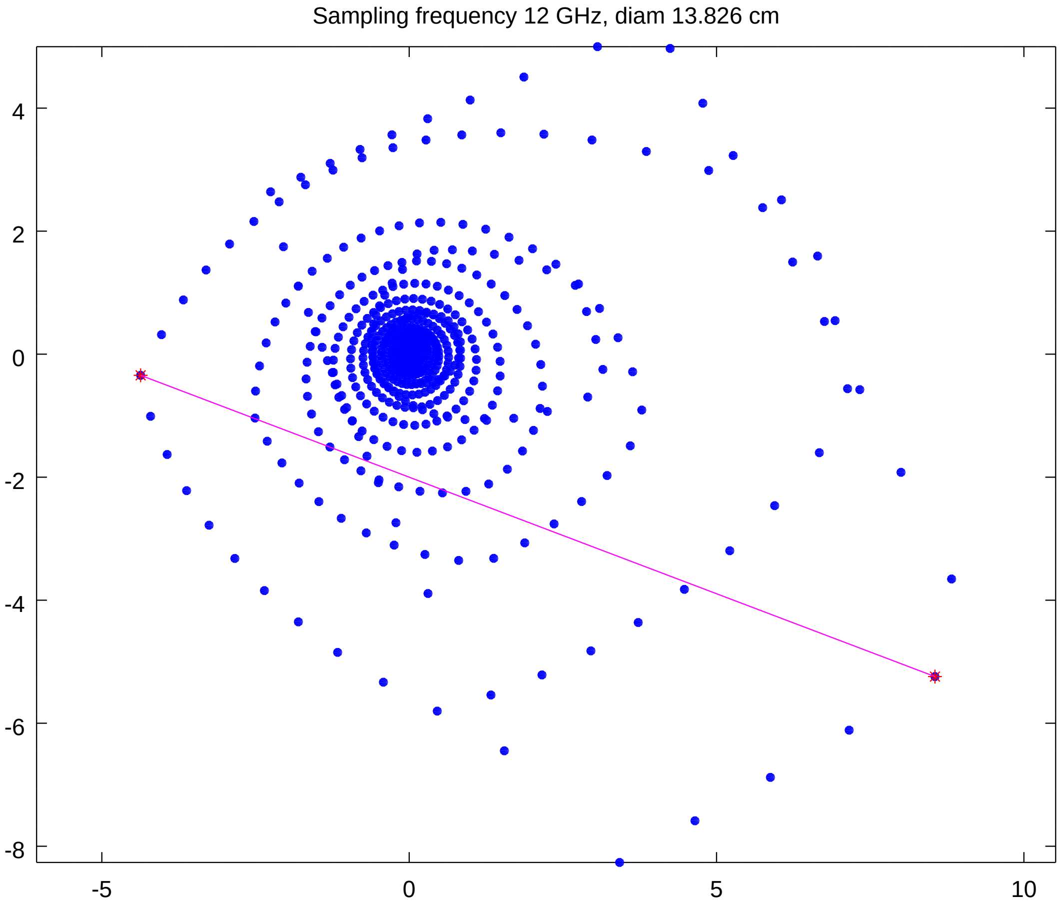




$$P = (1; 10; -2)\ [\mathrm{m}]$$



$P = (1; 10; -2)$ [m], receivers distance 1.6 m



Precision dependence on the sampling frequency

$$P = (-0.77; 2.84; 0.35)\ [\mathrm{m}]$$

frequency [GHz]	d_{min} [cm]	d_{max} [cm]	$d_{P_{\text{min}}}$ [cm]	$d_{P_{\text{max}}}$ [cm]	diam [cm]
3	0.016	24.835	−0.834	3.811	39.236
6	0.016	16.833	−0.834	1.264	21.734
12	0.016	6.417	−0.047	0.949	9.555

$$P = (1; 10; -2)\ [\mathrm{m}]$$

frequency [GHz]	d_{min} [cm]	d_{max} [cm]	$d_{P_{\text{min}}}$ [cm]	$d_{P_{\text{max}}}$ [cm]	diam [cm]
3	0.414	56.295	−3.382	0.695	71.499
6	0.052	39.529	−0.083	0.658	44.362
12	0.052	28.299	−0.083	0.382	35.167
12*	0.100	10.032	−0.754	0.302	13.826

* – receivers distance 1.6 m

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Conclusions

- Our investigation shows that for a higher sampling frequency the localization accuracy is acceptable for practical using.
- For larger distances the accuracy is smaller.
- Larger receiving antennas distances lead to a higher localization precision.
- Although TOA determination is, of course, much more complicated technical problem – it was useful to study time quantization effect itself.

Acknowledgment

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References

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[2] Sachs, J.: *Handbook of ultra-wideband short-range sensing: theory, sensors, applications*, John Wiley & Sons, 2013, doi: 10.1002/9783527651818.

[3] Buša, J.: *Target Localization by UWB Signals*, in I. Dimov et al. (Eds.): NMA 2014, LNCS 8962, 254–261, 2015, doi: 10.1007/978-3-319-15585-2_28.

[4] Švecová, M., Kocur, D., Demčák, J., Buša, J., and Gamcová, M.: *Through-floor localization of a static person by a multistatic UWB radar*, submitted to Electronics Letters, 2017.

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Thank you for your attention!