Smartphone-based Indoor Localization within a 13th Century Historic Building

Toni Fetzer, Frank Ebner, Markus Bullmann and Frank Deinzer
Faculty of Computer Science and Business Information Systems
University of Applied Sciences Würzburg-Schweinfurt
Würzburg, Germany
{toni.fetzer, frank.ebner, markus.bullmann, frank.deinzer}@fhws.de

Marcin Grzegorzek
Pattern Recognition Group
University of Siegen
Siegen, Germany
marcin.grzegorzek@uni-siegen.de

***Abstract*—Abstracttatatata**

I. Introduction

Setting up a localization solution for a building is a challenging and time-consuming task, especially in environments that are not build with localization in mind or do not provide any wireless infrastructure or both. Such scenarios are of special interest when old or even historical buildings serve a new purpose such as museums, shopping malls or retirement homes. In terms of European architecture, the problems emanating from these buildings worsen with age.

Such buildings are often full of nooks and crannies, what makes it hard for dynamical models using any kind of pedestrian dead reckoning (PDR). Here, the error accumulates not only over time, but also with the number of turns and steps made []. There is also a higher chance of detecting false or misplaced turns, what can cause the position estimation to lose track or get stuck within a demarcated area. Thus, this paper presents a very robust but realistic movement model using a navigation mesh based on triangles.

TODO into all three dimensions
what allows for very small map sizes

In localization systems using a sample based representation, like particle filters, the above mentioned problems can further lead to more advanced problems like sample impoverishment []. Sample impoverishment refers to a situation, in which the filter is unable to sample enough particles into proper regions of the building, caused by a high concentration of misplaced particles. Within this work we present a simple yet efficient method that enables a particle filter to fully recover from sample impoverishment.

TODO exact estimation fehlt hier noch

Many historical buildings, especially bigger ones like castles, monasteries or churches, are built of massive stone walls and have annexes from different historical periods out of different construction materials. This makes it hard for methods using received signal strengths (RSS) from Wi-Fi or Bluetooth, due to a high signal attenuation between different rooms. Many unknown quantities like the walls definitive material or thickness, makes it expensive to determine important parameters as the signals depletion over distance. Additionally, most wireless approaches adapt a line-of-sight assumption, the performance will be even more limited due to the irregularly shaped spatial structure of such buildings. Our approach tries to avoid those problems. We distributing a small number of simple and cheap Wi-Fi beacons over the whole building and instead of measuring their position inside the building, we use a optimization scheme based on some reference measurements.

A optimization scheme also helps against inaccuracies like wrong positioned access points or fingerprints caused by outdated or inaccurate building plans. It is obvious, that this could be solved by re-measuring the building, however this is a very time-consuming process requiring specialist hardware and in most cases a surveying engineer. However, this is contrary to most costumers expectations of a fast to deploy and low-cost solution. In addition, this is not only a question of costs incurred, but also for buildings under monumental protection, what does not allow for larger construction measures. Thus a highly flexible, robust and scalable system is needed to deal with such conditions, especially with the claim of a universal solution in multiple different environments. Smartphone-based solution was choosen...

To tackle the challenges above, a novel indoor localization approach is presented within this paper and then deployed to a 13th century building. The first 300 years the building was constructed and used as a convent, after that it had different functions ranging from a granary to an office for Bavarian officials. Since 1936, the $2500\,\mathrm{m}^2$ building acts as a museum of the medieval town Rothenburg ob der Tauber [].

We believe that by utilizing our localization approach to such a challenging scenario, it is possible to prove its flexibility, robustness and manageable effort.

Finally, the here presented work is an updated and highly refactored version of the winner of the smartphone-based competition at IPIN 2016 [].

[1]

wifi line of sight modelle versagen bei dicken wnden

TODO stark aufs wlan eingehen in den experimenten, das wir hier neue modelle brauchen, weil die line of sight annahme einfach zu schwach ist bei solchen wnden.

max. 1 Seite

- Deploying and indoor localisation system in the wild is not an easy task. especially in environments not planned

for ”zurechtfinden”.... within this work we investigate the capabilities of a localization approach within a 14th century kloster, now blabal as a museum. the 2500 m2 building has no digital infrastructure like ethernet, wifi or bluetooth. within the last 600 years the building durchging einige mayor baumanahmen, wie das hinzufgen von stockwerken oder ganzen gebudetrackte. leaving the build to be ein bunter mix (patchwork) unterschiedliche epochen, architekturen und verwendeter baumateriallien. (mehr dazu dann im indoormap kapitel)

- im museums umfeld bringt es dies und das weil..
- knappe kassen und kaum infrastruktur in den gebuden
- viele museun sind in sehr alten gebuden unter gebracht mit historisch gewachsener infrastruktur, welche nicht fr lokalisierung gemacht wurde
- es braucht eine kostengnstige lsung, welche dem anspruch eines museums gerecht wird.
- die wartung muss sehr gering ausfallen, da personal teuer
- keine spezialhardware, die besucher sollen mit eigenen gerten erkunden knnen. also smartphone-based.
- diese arbeit stellt daher ein smarthone-based lokalisierungssystem vor.
- zur lokalisierung wird neben pdr eine simple infrastruktur aus wifi beacons genutzt, deren position ber einige wenige fingerprints geschtzt werden.

II. Related Work

1/2 bis 3/4 Seite

- klassisches related work mit anderen systemen. Oder macht das hier keinen Sinn?
- bisschen ber fingerprinting herziehen
- bisschen ber uwb herziehen
- zum entschluss kommen, das normale menschen aktuell normale smartphones haben und deshalb solche lsungen just zu diesem zeitpunkt recht sinnvoll sind.
- auch der initiale aufwand sollte gering gehalten werden. also bisschen auf signalstrke verfahren eingehen.
- Also Reihenfolge:
- TOPTHEMA: In the Wild, also andere schwere Gebude.
- Karteninformationen
- Wifi-Beacons
- Optimierungsverfahren zur Positionsschtzung der AP’s
- PDR mit Smartphone
- unser ding mit particle filter und blah.

III. Recursive State Estimation

1/2 Seite, also kurz halten.

- klassiker.. also eigenltich alles beim alten.

IV. Transition

max. 1 Seite

A. Mapping

- Karte wird manuell ber ein Tool erstellt bei dem wnde, tren, fentser etc. eingezeichnet werden
- Karte unterscheidet bereiche, treppen etc.
- dort werden auch metainformationen wie ap etc. eingetragen
- daraus wird ein mesh generiert ber bla blub mit bla blub. cite cite cite :)

B. PDR

- aktuelle bewegungsmodell
- ...

V. Evaluation

3/4 - 1 Seite

A. Wifi

- kleine Wifi Beacons
- optimimierung der ap positionen ber schtzverfahren cite cite cite
- log dist model. knnen wir auch wieder viel citen.
- da vorher nie erwhnt, ggf. bisschen was ber VAPGrouping.

B. Barometer

- activity recognition ber barometer
- rauf/runter/treppe/aufzug etc. pp.

VI. Misc

A. State Estimation

1/2 bis 3/4 Seite

- weighted average
- max particle
- bulli methode (gleich citen :))

B. Sample Impoverishment

- einfache methode um das zu beheben.
- falls ichs schaff, wifi method ber die frank und ich mal gesprochen haben.

VII. Experiments

3 1/2 seiten sollten das schon werden. also eine ausfhrliche evaluation.

- Noch ein paar Dinge ber das gebude und das setup an sich
- auf was wurde geachtet, wie wurden die ap’s gesetzt. etc pp.
- wie wurde ground truth gemacht
- wie viele testaufnahmen...
- die einzelnen pfade gegenberstellen. (videos irgendwie bereitstellen?)
- schtzung der ap positionen vs reale ap positionen
- fehler gegenberstellen, genauigkeiten.
- allgemein an den parametern rumspielen: Anzahl Partikel (da wir das eig noch nicht so wirklich oft gemacht haben)
- estimation methoden gegenberstellen (diskussion aus bulli paper)
- aktive probleme aufzeigen (verlaufen, hngenblieben, schlechte ap signale ...

wir experimentieren auf allen vieren.

VIII. Conclusion

Conclusion Conclusion

References

[1] F. Ebner, T. Fetzer, F. Deinzer, and M. Grzegorzek, "On Wi-Fi Optimizations for Smartphone-based Indoor Localization," *IMWUT*, 2017, submitted.