

# A BLIND NAVIGATION SYSTEM USING RFID FOR INDOOR & OUTDOOR ENVIRONMENTS

U. SATHWASTA GOLLA, S. PRASANTH KUMAR, DR. K. MANIKANDAN

*Dept of ECE, VIT University, Vellore, Tamil Nadu, India*

---

## ABSTRACT

*In recent years, several approaches have been made to create systems that allow seamless tracking and navigation both in indoor and outdoor environments. This paper proposes a prototype which uses RFID technology to provide location-based services and navigation to the blind, or visually impaired. An overview of previous work made in the context of systems developed to assist the mobility of blind users. The reader reads the tag's ID by RFID communication. It then sends this information through a Bluetooth channel to the PDA device. The ID string and data is processed and then an output is sent through another Bluetooth channel to the headsets which finally produce the audio output that is used by the visually impaired person.*

**Keywords:** ARM7, RFID Tags, RFID Reader, Bluetooth, Android phone.

## INTRODUCTION

The goal of Blind-Aid project is to develop navigational assistance technology for the blind or visually impaired. Specifically, we seek to develop a portable Electronic Travel Aid (ETA) for visually impaired users, along with the accompanying radio frequency identification (RFID) localization infrastructure used to equip buildings [1]. The problem of navigation assistance has been addressed in academia, primarily from the angle of human-computer interactions, and in the industry, by proposing some commercially viable systems that utilize recent advances in mobile device and Bluetooth technology.

## REALTED WORK

In this paper, we proposed an RFID based navigation system for in-building navigation for blind people. Our proposed system helps blind people to find a shortest path from his current location to a destination. It also helps to them when they get lost by automatically detecting the lost and recalculate a new route to the same destination. Our proposed system embeds RFID tags into a footpath that can be read by an RFID reader with a cane antenna. Our proposed work can also be used as a tourist guide system for a museum or a navigation system for a rescue in hazardous environments where it is difficult to find an emergency exit.

## LITERATURE SURVEY

Nowadays, navigation systems are widely used to find the correct path, or the quickest, between two places. These systems use the *Global Positioning System* (GPS) and only work well in outdoor environment since GPS signals cannot easily penetrate and/or are greatly degraded inside of buildings. Several technologies have been proposed to make navigation inside of buildings possible. One such technology is Radio-Frequency Identification (RFID). In the case of outside environments, some hybrid systems have been proposed that use GPS as main information source and RFID for corrections and location error minimization. In this article we propose a navigation system that uses RFID as the main technology to guide people with visual impairment in unfamiliar environments, both indoor and outdoor, complementing the traditional white cane and providing information about the user's geographical context. For visually impaired people, outdoor pedestrian mobility is very difficult and often dangerous. The visually impaired commonly rely on a cane and/or a guide dog to assist them in efficiently reaching a desired destination without harm. However, this approach is successful only if the majority of the path to the destination is already known to the affected person (or to the guide dog). In a world in which perception extends to the tip of the blind's cane, orientation is very difficult, especially in environments which were not designed for blind people. To better understand the problem we should point out that orientation is essentially based on the recognition.

## METHODOLOGY

The proposed blind navigation system is composed of three subsystems, the track infrastructure, the navigation device, and the navigation voice. The track infrastructure is composed of RFID tags. Each tag can be embedded into a stone block and put it on a footpath. The RFID stone block is also used by blind people for navigation. The type of RFID tags is selected upon the usage. The tags can be installed along the footpath or at least at the junction of the footpath. The tag stores the tag ID, and the tag location. To reduce the massive amount of location information for users, the location can be hierarchically divided; for example, each tag location is identified by a location area, a path. In this paper, the distance is approx 7-10 centimeters. The frequency range of RFID (radio frequency identification) is of low frequency range (30 KHz to 500 KHz). Keil software is used in this project, which is burn in the ARM7 – LPC2148 microcontroller which is highly efficient device with RFID TAGS is used.

- RFID reader is mounted on dry printed circuit board.
- Some mechanical applications like stick, plate (in which PCB is mounted), wheel etc.
- 3.5 mm jack ear phone is used to hear the output response.
- 12 v supplies are provided to the circuitry to operate.



Fig1. The guidance system for a blind person

Secondly, the navigation device is an embedded system that is equipped with a microprocessor unit (MCU), an RFID reader, a communication module, a user interface module, a memory module. The MCU is ARM7TDMI-S based high-performance 32-bit RISC Microcontroller with Thumb extensions 512KB on-chip Flash ROM with In-System Programming (ISP) and In-Application Programming (IAP), 32KB RAM, Two UARTs, one with full modem interface. The communication module communicates with the navigation data to send a request and to receive a planned route from the server for navigation. We use the Bluetooth module to convey information via wireless networks.

## RESULTS WITH DISCUSSION

We have built a system prototype including a simulated with 10 tags to form a grid paths. Each tag contains Tag ID and its location. The actual size of the prototype is about 12 x 18 x 6 cm in dimension and about 0.5 kg by weight, not including the tag reader. The tag reader is about 22 x 12 x 5 cm in dimension and about 0.4 kg by weight. The device is portable equipped with a headphone for blind navigation where only voice is used to guide the users to navigate. The device is operated by a rechargeable 12V battery that can last about 6 hours. The device is attached for blind people.

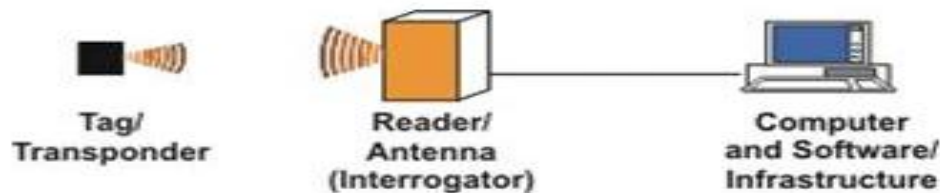
We have tested our system by a simulation of the navigation. The system prototype has shown the promising result although its size is still large. We also found some communication delay in the device to connect for the first time. There is also some delay in the voice playback where the voice file is read from MMC module. In our future work, we will reduce the cycle delay by using

a pre-start cycle. Additionally, we will improve the voice playback module by storing some frequently-used words in the ROM and pre-load some words in the RAM module for faster speech transfer or using a speech synthesizer to generate voice.

## DETAILS OF HARDWARE AND SOFTWARE

### RFID Reader:

In a typical RFID system tags are attached to objects. Each tag has a certain amount of internal memory (EEPROM) in which it stores information about the object, such as its unique ID (serial) number, or in some cases more details including manufacture date and product composition. When these tags pass through a field generated by a reader, they transmit this information back to the reader, thereby identifying the object. Any corresponding tag in the vicinity of the reader will detect the signal and use the energy from it to wake up and supply operating power to its internal circuits. The tags must use the power they receive to operate their integrated circuits and return a signal with their ID to the reader. Once the Tag has decoded the signal as valid, it replies to the reader, and indicates its presence by modulating (affecting) the reader field.



### Bluetooth technology:

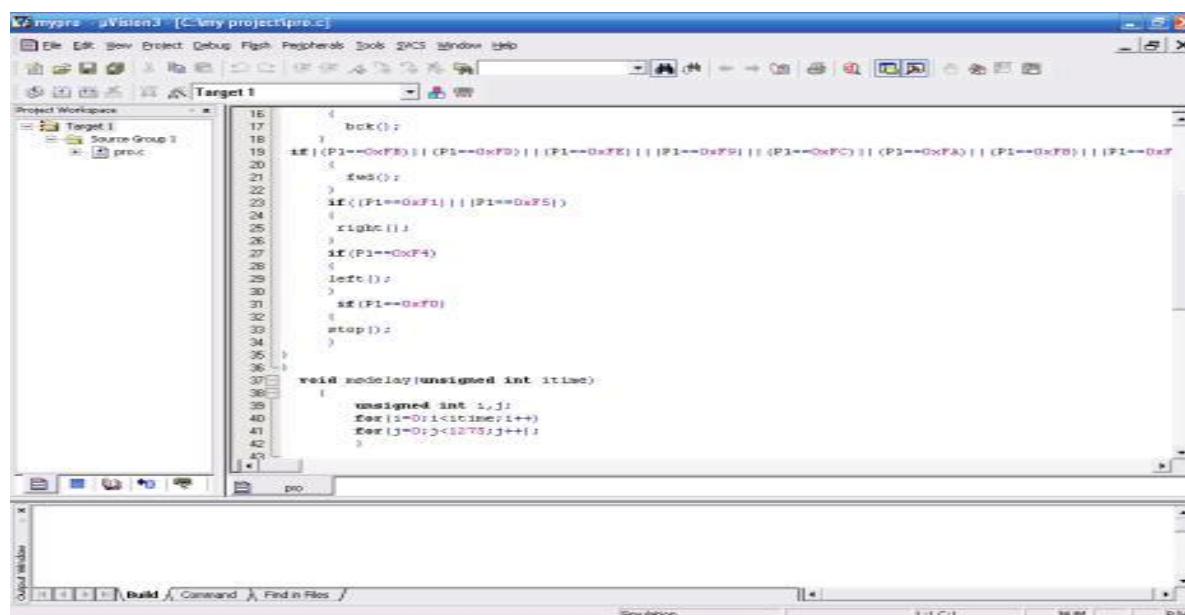
The Bluetooth technology supports asynchronous data channel, or 3 simultaneous synchronous voice channels, or a channel which supports asynchronous data and synchronous voice. Bluetooth was selected as our way of communicating PDA/Mobile with a central system. The reason Bluetooth was selected over Bluetooth for various reasons. First of all, Bluetooth security is less complex and more stable than that of Wi-Fi. Bluetooth manages a security measure of only permitting certain selected devices to interact with them; Wi-Fi in the other hand establishes a WEP key that has been known to be cracked. Another reason that Bluetooth was selected over Wi-Fi is that Bluetooth has a shorter range of signal emission than Wi-Fi. This is a pro because the shorter the range the less the amount intruders that will try to infiltrate your home system

### Bluetooth Features:

- ✓ *Standard 3V3 operation*
- ✓ *Bluetooth standard Ver. 2.0 + EDR compliant*

- ✓ *Low current consumption*
- ✓ *Hold, Sniff, Park, Deep sleep modes*
- ✓ *Support for up to seven slaves*
- ✓ *Supports UART,USB,PCM,I2C interface to host system interface*
- ✓ *SPP(Serial Port Protocol) firmware*

## PROGRAMING DONE ON KEIL SOFTWARE



```
16      4      back();
17      5
18      6
19      7      if((P1==0x0E)|| (P1==0x0D)|| (P1==0x0E)|| (P1==0x0E)|| (P1==0x0C)|| (P1==0x0A)|| (P1==0x0B)|| (P1==0x0F
20      8
21      9      }
22      10     }
23      11     if((P1==0x01)|| (P1==0x05))
24      12     {
25      13     right();
26      14     }
27      15     if(P1==0x04)
28      16     {
29      17     left();
30      18     }
31      19     if(P1==0x0D)
32      20     {
33      21     stop();
34      22     }
35      23     }
36      24     }
37      25     }
38      26     }
39      27     }
40      28     }
41      29     }
42      30     }
43      31     }
44      32     }
45      33     }
46      34     }
47      35     }
48      36     }
49      37     }
50      38     }
51      39     }
52      40     }
53      41     }
54      42     }
55      43     }
56      44     }
57      45     }
58      46     }
59      47     }
60      48     }
61      49     }
62      50     }
63      51     }
64      52     }
65      53     }
66      54     }
67      55     }
68      56     }
69      57     }
70      58     }
71      59     }
72      60     }
73      61     }
74      62     }
75      63     }
76      64     }
77      65     }
78      66     }
79      67     }
80      68     }
81      69     }
82      70     }
83      71     }
84      72     }
85      73     }
86      74     }
87      75     }
88      76     }
89      77     }
90      78     }
91      79     }
92      80     }
93      81     }
94      82     }
95      83     }
96      84     }
97      85     }
98      86     }
99      87     }
100     88     }
101     89     }
102     90     }
103     91     }
104     92     }
105     93     }
106     94     }
107     95     }
108     96     }
109     97     }
110     98     }
111     99     }
112     100    }
113     101    }
114     102    }
115     103    }
116     104    }
117     105    }
118     106    }
119     107    }
120     108    }
121     109    }
122     110    }
123     111    }
124     112    }
125     113    }
126     114    }
127     115    }
128     116    }
129     117    }
130     118    }
131     119    }
132     120    }
133     121    }
134     122    }
135     123    }
136     124    }
137     125    }
138     126    }
139     127    }
140     128    }
141     129    }
142     130    }
143     131    }
144     132    }
145     133    }
146     134    }
147     135    }
148     136    }
149     137    }
150     138    }
151     139    }
152     140    }
153     141    }
154     142    }
155     143    }
156     144    }
157     145    }
158     146    }
159     147    }
160     148    }
161     149    }
162     150    }
163     151    }
164     152    }
165     153    }
166     154    }
167     155    }
168     156    }
169     157    }
170     158    }
171     159    }
172     160    }
173     161    }
174     162    }
175     163    }
176     164    }
177     165    }
178     166    }
179     167    }
180     168    }
181     169    }
182     170    }
183     171    }
184     172    }
185     173    }
186     174    }
187     175    }
188     176    }
189     177    }
190     178    }
191     179    }
192     180    }
193     181    }
194     182    }
195     183    }
196     184    }
197     185    }
198     186    }
199     187    }
200     188    }
201     189    }
202     190    }
203     191    }
204     192    }
205     193    }
206     194    }
207     195    }
208     196    }
209     197    }
210     198    }
211     199    }
212     200    }
213     201    }
214     202    }
215     203    }
216     204    }
217     205    }
218     206    }
219     207    }
220     208    }
221     209    }
222     210    }
223     211    }
224     212    }
225     213    }
226     214    }
227     215    }
228     216    }
229     217    }
230     218    }
231     219    }
232     220    }
233     221    }
234     222    }
235     223    }
236     224    }
237     225    }
238     226    }
239     227    }
240     228    }
241     229    }
242     230    }
243     231    }
244     232    }
245     233    }
246     234    }
247     235    }
248     236    }
249     237    }
250     238    }
251     239    }
252     240    }
253     241    }
254     242    }
255     243    }
256     244    }
257     245    }
258     246    }
259     247    }
260     248    }
261     249    }
262     250    }
263     251    }
264     252    }
265     253    }
266     254    }
267     255    }
268     256    }
269     257    }
270     258    }
271     259    }
272     260    }
273     261    }
274     262    }
275     263    }
276     264    }
277     265    }
278     266    }
279     267    }
280     268    }
281     269    }
282     270    }
283     271    }
284     272    }
285     273    }
286     274    }
287     275    }
288     276    }
289     277    }
290     278    }
291     279    }
292     280    }
293     281    }
294     282    }
295     283    }
296     284    }
297     285    }
298     286    }
299     287    }
300     288    }
301     289    }
302     290    }
303     291    }
304     292    }
305     293    }
306     294    }
307     295    }
308     296    }
309     297    }
310     298    }
311     299    }
312     300    }
313     301    }
314     302    }
315     303    }
316     304    }
317     305    }
318     306    }
319     307    }
320     308    }
321     309    }
322     310    }
323     311    }
324     312    }
325     313    }
326     314    }
327     315    }
328     316    }
329     317    }
330     318    }
331     319    }
332     320    }
333     321    }
334     322    }
335     323    }
336     324    }
337     325    }
338     326    }
339     327    }
340     328    }
341     329    }
342     330    }
343     331    }
344     332    }
345     333    }
346     334    }
347     335    }
348     336    }
349     337    }
350     338    }
351     339    }
352     340    }
353     341    }
354     342    }
355     343    }
356     344    }
357     345    }
358     346    }
359     347    }
360     348    }
361     349    }
362     350    }
363     351    }
364     352    }
365     353    }
366     354    }
367     355    }
368     356    }
369     357    }
370     358    }
371     359    }
372     360    }
373     361    }
374     362    }
375     363    }
376     364    }
377     365    }
378     366    }
379     367    }
380     368    }
381     369    }
382     370    }
383     371    }
384     372    }
385     373    }
386     374    }
387     375    }
388     376    }
389     377    }
390     378    }
391     379    }
392     380    }
393     381    }
394     382    }
395     383    }
396     384    }
397     385    }
398     386    }
399     387    }
400     388    }
401     389    }
402     390    }
403     391    }
404     392    }
405     393    }
406     394    }
407     395    }
408     396    }
409     397    }
410     398    }
411     399    }
412     400    }
413     401    }
414     402    }
415     403    }
416     404    }
417     405    }
418     406    }
419     407    }
420     408    }
421     409    }
422     410    }
423     411    }
424     412    }
425     413    }
426     414    }
427     415    }
428     416    }
429     417    }
430     418    }
431     419    }
432     420    }
433     421    }
434     422    }
435     423    }
436     424    }
437     425    }
438     426    }
439     427    }
440     428    }
441     429    }
442     430    }
443     431    }
444     432    }
445     433    }
446     434    }
447     435    }
448     436    }
449     437    }
450     438    }
451     439    }
452     440    }
453     441    }
454     442    }
455     443    }
456     444    }
457     445    }
458     446    }
459     447    }
460     448    }
461     449    }
462     450    }
463     451    }
464     452    }
465     453    }
466     454    }
467     455    }
468     456    }
469     457    }
470     458    }
471     459    }
472     460    }
473     461    }
474     462    }
475     463    }
476     464    }
477     465    }
478     466    }
479     467    }
480     468    }
481     469    }
482     470    }
483     471    }
484     472    }
485     473    }
486     474    }
487     475    }
488     476    }
489     477    }
490     478    }
491     479    }
492     480    }
493     481    }
494     482    }
495     483    }
496     484    }
497     485    }
498     486    }
499     487    }
500     488    }
501     489    }
502     490    }
503     491    }
504     492    }
505     493    }
506     494    }
507     495    }
508     496    }
509     497    }
510     498    }
511     499    }
512     500    }
513     501    }
514     502    }
515     503    }
516     504    }
517     505    }
518     506    }
519     507    }
520     508    }
521     509    }
522     510    }
523     511    }
524     512    }
525     513    }
526     514    }
527     515    }
528     516    }
529     517    }
530     518    }
531     519    }
532     520    }
533     521    }
534     522    }
535     523    }
536     524    }
537     525    }
538     526    }
539     527    }
540     528    }
541     529    }
542     530    }
543     531    }
544     532    }
545     533    }
546     534    }
547     535    }
548     536    }
549     537    }
550     538    }
551     539    }
552     540    }
553     541    }
554     542    }
555     543    }
556     544    }
557     545    }
558     546    }
559     547    }
560     548    }
561     549    }
562     550    }
563     551    }
564     552    }
565     553    }
566     554    }
567     555    }
568     556    }
569     557    }
570     558    }
571     559    }
572     560    }
573     561    }
574     562    }
575     563    }
576     564    }
577     565    }
578     566    }
579     567    }
580     568    }
581     569    }
582     570    }
583     571    }
584     572    }
585     573    }
586     574    }
587     575    }
588     576    }
589     577    }
590     578    }
591     579    }
592     580    }
593     581    }
594     582    }
595     583    }
596     584    }
597     585    }
598     586    }
599     587    }
600     588    }
601     589    }
602     590    }
603     591    }
604     592    }
605     593    }
606     594    }
607     595    }
608     596    }
609     597    }
610     598    }
611     599    }
612     600    }
613     601    }
614     602    }
615     603    }
616     604    }
617     605    }
618     606    }
619     607    }
620     608    }
621     609    }
622     610    }
623     611    }
624     612    }
625     613    }
626     614    }
627     615    }
628     616    }
629     617    }
630     618    }
631     619    }
632     620    }
633     621    }
634     622    }
635     623    }
636     624    }
637     625    }
638     626    }
639     627    }
640     628    }
641     629    }
642     630    }
643     631    }
644     632    }
645     633    }
646     634    }
647     635    }
648     636    }
649     637    }
650     638    }
651     639    }
652     640    }
653     641    }
654     642    }
655     643    }
656     644    }
657     645    }
658     646    }
659     647    }
660     648    }
661     649    }
662     650    }
663     651    }
664     652    }
665     653    }
666     654    }
667     655    }
668     656    }
669     657    }
670     658    }
671     659    }
672     660    }
673     661    }
674     662    }
675     663    }
676     664    }
677     665    }
678     666    }
679     667    }
680     668    }
681     669    }
682     670    }
683     671    }
684     672    }
685     673    }
686     674    }
687     675    }
688     676    }
689     677    }
690     678    }
691     679    }
692     680    }
693     681    }
694     682    }
695     683    }
696     684    }
697     685    }
698     686    }
699     687    }
700     688    }
701     689    }
702     690    }
703     691    }
704     692    }
705     693    }
706     694    }
707     695    }
708     696    }
709     697    }
710     698    }
711     699    }
712     700    }
713     701    }
714     702    }
715     703    }
716     704    }
717     705    }
718     706    }
719     707    }
720     708    }
721     709    }
722     710    }
723     711    }
724     712    }
725     713    }
726     714    }
727     715    }
728     716    }
729     717    }
730     718    }
731     719    }
732     720    }
733     721    }
734     722    }
735     723    }
736     724    }
737     725    }
738     726    }
739     727    }
740     728    }
741     729    }
742     730    }
743     731    }
744     732    }
745     733    }
746     734    }
747     735    }
748     736    }
749     737    }
750     738    }
751     739    }
752     740    }
753     741    }
754     742    }
755     743    }
756     744    }
757     745    }
758     746    }
759     747    }
760     748    }
761     749    }
762     750    }
763     751    }
764     752    }
765     753    }
766     754    }
767     755    }
768     756    }
769     757    }
770     758    }
771     759    }
772     760    }
773     761    }
774     762    }
775     763    }
776     764    }
777     765    }
778     766    }
779     767    }
780     768    }
781     769    }
782     770    }
783     771    }
784     772    }
785     773    }
786     774    }
787     775    }
788     776    }
789     777    }
790     778    }
791     779    }
792     780    }
793     781    }
794     782    }
795     783    }
796     784    }
797     785    }
798     786    }
799     787    }
800     788    }
801     789    }
802     790    }
803     791    }
804     792    }
805     793    }
806     794    }
807     795    }
808     796    }
809     797    }
810     798    }
811     799    }
812     800    }
813     801    }
814     802    }
815     803    }
816     804    }
817     805    }
818     806    }
819     807    }
820     808    }
821     809    }
822     810    }
823     811    }
824     812    }
825     813    }
826     814    }
827     815    }
828     816    }
829     817    }
830     818    }
831     819    }
832     820    }
833     821    }
834     822    }
835     823    }
836     824    }
837     825    }
838     826    }
839     827    }
840     828    }
841     829    }
842     830    }
843     831    }
844     832    }
845     833    }
846     834    }
847     835    }
848     836    }
849     837    }
850     838    }
851     839    }
852     840    }
853     841    }
854     842    }
855     843    }
856     844    }
857     845    }
858     846    }
859     847    }
860     848    }
861     849    }
862     850    }
863     851    }
864     852    }
865     853    }
866     854    }
867     855    }
868     856    }
869     857    }
870     858    }
871     859    }
872     860    }
873     861    }
874     862    }
875     863    }
876     864    }
877     865    }
878     866    }
879     867    }
880     868    }
881     869    }
882     870    }
883     871    }
884     872    }
885     873    }
886     874    }
887     875    }
888     876    }
889     877    }
890     878    }
891     879    }
892     880    }
893     881    }
894     882    }
895     883    }
896     884    }
897     885    }
898     886    }
899     887    }
900     888    }
901     889    }
902     890    }
903     891    }
904     892    }
905     893    }
906     894    }
907     895    }
908     896    }
909     897    }
910     898    }
911     899    }
912     900    }
913     901    }
914     902    }
915     903    }
916     904    }
917     905    }
918     906    }
919     907    }
920     908    }
921     909    }
922     910    }
923     911    }
924     912    }
925     913    }
926     914    }
927     915    }
928     916    }
929     917    }
930     918    }
931     919    }
932     920    }
933     921    }
934     922    }
935     923    }
936     924    }
937     925    }
938     926    }
939     927    }
940     928    }
941     929    }
942     930    }
943     931    }
944     932    }
945     933    }
946     934    }
947     935    }
948     936    }
949     937    }
950     938    }
951     939    }
952     940    }
953     941    }
954     942    }
955     943    }
956     944    }
957     945    }
958     946    }
959     947    }
960     948    }
961     949    }
962     950    }
963     951    }
964     952    }
965     953    }
966     954    }
967     955    }
968     956    }
969     957    }
970     958    }
971     959    }
972     960    }
973     961    }
974     962    }
975     963    }
976     964    }
977     965    }
978     966    }
979     967    }
980     968    }
981     969    }
982     970    }
983     971    }
984     972    }
985     973    }
986     974    }
987     975    }
988     976    }
989     977    }
990     978    }
991     979    }
992     980    }
993     981    }
994     982    }
995     983    }
996     984    }
997     985    }
998     986    }
999     987    }
1000    988    }
1001    989    }
1002    990    }
1003    991    }
1004    992    }
1005    993    }
1006    994    }
1007    995    }
1008    996    }
1009    997    }
1010    998    }
1011    999    }
1012    1000    }
1013    1001    }
1014    1002    }
1015    1003    }
1016    1004    }
1017    1005    }
1018    1006    }
1019    1007    }
1020    1008    }
1021    1009    }
1022    1010    }
1023    1011    }
1024    1012    }
1025    1013    }
1026    1014    }
1027    1015    }
1028    1016    }
1029    1017    }
1030    1018    }
1031    1019    }
1032    1020    }
1033    1021    }
1034    1022    }
1035    1023    }
1036    1024    }
1037    1025    }
1038    1026    }
1039    1027    }
1040    1028    }
1041    1029    }
1042    1030    }
1043    1031    }
1044    1032    }
1045    1033    }
1046    1034    }
1047    1035    }
1048    1036    }
1049    1037    }
1050    1038    }
1051    1039    }
1052    1040    }
1053    1041    }
1054    1042    }
1055    1043    }
1056    1044    }
1057    1045    }
1058    1046    }
1059    1047    }
1060    1048    }
1061    1049    }
1062    1050    }
1063    1051    }
1064    1052    }
1065    1053    }
1066    1054    }
1067    1055    }
1068    1056    }
1069    1057    }
1070    1058    }
1071    1059    }
1072    1060    }
1073    1061    }
1074    1062    }
1075    1063    }
1076    1064    }
1077    1065    }
1078    1066    }
1079    1067    }
1080    1068    }
1081    1069    }
1082    1070    }
1083    1071    }
1084    1072    }
1085    1073    }
1086    1074    }
1087    1075    }
1088    1076    }
1089    1077    }
1
```

- [5] S. Willis, S. Helal, "RFID information grid for blind navigation and way finding," in Proceedings of the Ninth IEEE International Symposium on Wearable Computers, 2005 18-21 Oct. 2005.
- [6] Jongwhoa Na, The Blind Interactive Guide System Using RFID-Based Indoor Positioning System, in Computers Helping People with Special Needs, LNCS Volume 4061, ISBN 978-3-540-36020-9, 2006.
- [7] Sergio Polito and et.al., Performance Evaluation of Active RFID Location Systems based on RF Power Measures, in the proceedings of the IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2007), September 2007.
- [8] World Health Organization, "WHO — Visual Impairment and Blindness." Fact Sheet No. 282, 2014
- [9] S. Shoval, I. Ulrich, and J. Borenstein, "NavBelt and the Guide-Cane [obstacle-avoidance systems for the blind and visually impaired]" IEEE Robotics and Automation Magazine, vol. 10, no. 1, pp. 9– 20, 2013
- [10] A.M Kassim, Jamaluddin, M.H., Yaacob, M.R., Anwar, N.S.N., Sani, Z.M., Noordin, A., "Design and development of MY 2nd EYE for visually impaired people" 2011 IEEE Symposium on Industrial Electronics and Applications (ISIEA), pp. 700–703, 2011
- [11] A.M Kassim, M.S Jamri, M.S.M Aras, M.Z.A Rashid, MR Yaacob, "Design and development of obstacle detection and warning device for above abdomen level" 2012 12th International Conference on Control, Automation and Systems (ICCAS), pp. 410–413, 2012
- [12] So-In Chakchai, S. Arch-int, C. Phaudphut, K. Rujirakul, N. Weeramongkonlert, "A new mobile phone system architecture for the navigational travelling blind", *Computer Science and Software Engineering (JCSSE) 2012 International Joint Conference on*, pp. 54-59, 2012.
- [13] A.M Kassim, A.Z Shukor, C.X Zhi, T Yasuno, "Performance Study of Developed SMART EYE for Visually Impaired people" *Australian Journal of Basic and Applied Sciences*, 7 (14) pp. 633–639, 2013.