WALE: A Weighted Adaptive Location Estimation Algorithm
--Manuscript Draft--

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Abstract:	Indoor pervasive applications depend on reliable indoor localization solutions. Indoor localization using WiFi is gaining ubiquitous usage owing to its simplicity and inexpensiveness. A conventional method of localization is trilateration, which can be accomplished using signal strength or time of flight of a radio signal between receiver and transmitter. However, trilateration is prone to errors in accuracy that can occur due to various factors. A common reason for the failure of trilateration is due to the errors in distance estimation resulting in a poor quality of trilateration. In this paper, we propose a novel Weighted Adaptive Location Estimation (WALE) algorithm. The proposed WALE algorithm provides an accurate localization in comparison to trilateration by taking into account the quality and properties of the circle overlaps. Based on the overlap properties a distance re-estimation and classification of points based on whether they are trilaterable is performed. A maximum likelihood estimation over a weighted grid of this region provides the location estimate. Our experiments over real indoor test-beds have demonstrated that our algorithm provides high accuracies with high stability in comparison to other algorithms. We achieve high accuracies ranging from 1.20m to 2.20m in majority of the cases and an average of 2.98m in a large office space with a standard deviation of 1.65.
Response to Reviewers:	Respected Dr. Vincenzo Loia and Editor(s) and reviewers, Thank you for your valuable and positive review comments for the Manuscript entitled "WALE: A Weighted Adaptive Location Estimation Algorithm". We are delighted that you are interested in the paper and appreciate your comments and valuable suggestions. We have carefully reviewed the comments and revised the manuscript as advised. Our responses to the comments have been addressed and we have taken efforts to

address the reviewer concerns as best as possible.

We hope the revised version is now suitable for publication and look forward to hear from you in due course.

RESPONSES FOR THE COMMENTS:

The primary comments regarding the paper have been with respect to the structuring of the paper and description of algorithm. There was also concerns about grammatical errors.

>> We have reworked the structure of the paper and enhanced the writing in certain sections so that the clarity is improved specifically in Sections 3 and 4. Examples and figures have been added to improve readability. Additionally, we have re-structured our paragraphs in order to convey meanings more accurately and maintain a certain flow of the general idea. We have added references in multiple places throughout the manuscript and explained methods and keywords better. We regret the presence of grammatical errors and typos, and have made sure to address this in the revised version. We have fixed all the grammatical and semantical errors, reworded sentences and cropped images better.

Some of the specific changes in addition to the above are mentioned below.

1. "I recommend to avoid repetitive "we wil describe.... " since makes it difficult to follow in some points the scientific approach."

>> We have removed all the repetitive phrases that we have used in the manuscript.

2. The introduction need to provide more relevant references.

>> References have been added wherever relevant in the introduction.

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Package: expl3 2016/03/28 v6468 L3 programming layer (code)
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L3 Module: l3names 2016/03/11 v6433 L3 Namespace for primitives
L3 Module: l3basics 2015/11/22 v6315 L3 Basic definitions
L3 Module: l3expan 2015/09/10 v5983 L3 Argument expansion
L3 Module: l3tl 2016/03/26 v6465 L3 Token lists
L3 Module: l3str 2016/03/24 v6441 L3 Strings
L3 Module: l3seq 2015/08/05 v5777 L3 Sequences and stacks
L3 Module: l3int 2016/03/24 v6441 L3 Integers
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L3 Module: l3msg 2016/03/26 v6464 L3 Messages
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\g_tmpa_muskip=\muskip14
\g_tmpb_muskip=\muskip15
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\l__coffin_offset_y_dim=\dimen122
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\l_tmpb_coffin=\box39
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\l__coffin_display_pole_coffin=\box42
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L3 Module: l3sys 2015/09/25 v6087 L3 Experimental system/runtime
functions
L3 Module: l3candidates 2016/03/25 v6456 L3 Experimental additions to
l3kernel
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functions
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7397.
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(HO)
) (c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/ltxcmds.sty
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(c:/TeXLive/2015/texmf-dist/tex/latex/base/ifthen.sty
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) (c:/TeXLive/2015/texmf-dist/tex/latex/algorithm2e/algorithm2e.sty
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releases
- algorithm2e-discussion@lirmm.fr mailing list for discussion about
package
subscribe by emailing sympa@lirmm.fr with 'subscribe <list> <firstname
name>'
- Author: Christophe Fiorio (christophe.fiorio@umontpellier.fr)
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\skiphlne=\skip61
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Package: babel 2016/02/24 3.9q The Babel package
(c:/TeXLive/2015/texmf-dist/tex/generic/babel-english/english.ldf
Language: english 2012/08/20 v3.3p English support from the babel system
(c:/TeXLive/2015/texmf-dist/tex/generic/babel/babel.def
File: babel.def 2016/02/24 3.9q Babel common definitions
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\l@canadian = a dialect from \language\l@american
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LaTeX Font Info:    ... okay on input line 19.
LaTeX Font Info:    Checking defaults for OMS/cmsy/m/n on input line 19.
LaTeX Font Info:    ... okay on input line 19.
LaTeX Font Info:    Checking defaults for OMX/cmex/m/n on input line 19.
LaTeX Font Info:    ... okay on input line 19.
LaTeX Font Info:    Checking defaults for U/cmr/m/n on input line 19.
LaTeX Font Info:    ... okay on input line 19.
Unknown journal: specify \journalname{<name of your journal>} in preambel

(c:/TeXLive/2015/texmf-dist/tex/latex/beamer/translator/dicts/translator-
basic-
dictionary/translator-basic-dictionary-English.dict
Dictionary: translator-basic-dictionary, Language: English
) (c:/TeXLive/2015/texmf-dist/tex/latex/siunitx/siunitx-abbreviations.cfg
File: siunitx-abbreviations.cfg 2016/03/01 v2.6q siunitx: Abbreviated
units
) (c:/TeXLive/2015/texmf-dist/tex/context/base/supp-pdf.mkii
[Loading MPS to PDF converter (version 2006.09.02).]
\scratchcounter=\count162
\scratchdimen=\dimen170
\scratchbox=\box59
\nofMPsegments=\count163
\nofMParguments=\count164
\everyMPshowfont=\toks19
\MPscratchCnt=\count165
\MPscratchDim=\dimen171
\MPnumerator=\count166
\makeMPintoPDFobject=\count167
\everyMPtoPDFconversion=\toks20
) (c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/pdftexcmds.sty
Package: pdftexcmds 2011/11/29 v0.20 Utility functions of pdfTeX for
LuaTeX (HO
)
(c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/ifluatex.sty
Package: ifluatex 2010/03/01 v1.3 Provides the ifluatex switch (HO)
```

```
1
2
3
4      Package ifluatex Info: LuaTeX not detected.
5      ) (c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/ifpdf.sty
6      Package: ifpdf 2011/01/30 v2.3 Provides the ifpdf switch (HO)
7      Package ifpdf Info: pdfTeX in PDF mode is detected.
8      )
9      Package pdftexcmds Info: LuaTeX not detected.
10     Package pdftexcmds Info: \pdf@primitive is available.
11     Package pdftexcmds Info: \pdf@ifprimitive is available.
12     Package pdftexcmds Info: \pdfdraftmode found.
13     ) (c:/TeXLive/2015/texmf-dist/tex/latex/oberdiek/epstopdf-base.sty
14     Package: epstopdf-base 2010/02/09 v2.5 Base part for package epstopdf
15     (c:/TeXLive/2015/texmf-dist/tex/latex/oberdiek/grfext.sty
16     Package: grfext 2010/08/19 v1.1 Manage graphics extensions (HO)
17     (c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/kvdefinekeys.sty
18     Package: kvdefinekeys 2011/04/07 v1.3 Define keys (HO)
19     )) (c:/TeXLive/2015/texmf-dist/tex/latex/oberdiek/kvoptions.sty
20     Package: kvoptions 2011/06/30 v3.11 Key value format for package options
21     (HO)
22     (c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/kvsetkeys.sty
23     Package: kvsetkeys 2012/04/25 v1.16 Key value parser (HO)
24     (c:/TeXLive/2015/texmf-dist/tex/generic/oberdiek/etexcmds.sty
25     Package: etexcmds 2011/02/16 v1.5 Avoid name clashes with e-TeX commands
26     (HO)
27     Package etexcmds Info: Could not find \expanded.
28     (etexcmds)                That can mean that you are not using pdfTeX 1.50
29     or
30     (etexcmds)                that some package has redefined \expanded.
31     (etexcmds)                In the latter case, load this package earlier.
32     )))
33     Package grfext Info: Graphics extension search list:
34     (grfext)
35     [.png,.pdf,.jpg,.mps,.jpeg,.jbig2,.jb2,.PNG,.PDF,.JPG,.JPE
36     G,.JBIG2,.JB2,.eps]
37     (grfext)                \AppendGraphicsExtensions on input line 452.
38     (c:/TeXLive/2015/texmf-dist/tex/latex/latexconfig/epstopdf-sys.cfg
39     File: epstopdf-sys.cfg 2010/07/13 v1.3 Configuration of (r)epstopdf for
40     TeX Liv
41     e
42     ))
43     \c__siunitx_mathsf_int=\count168
44     LaTeX Font Info:    Calculating math sizes for size <9.5> on input line
45     19.
46
47     LaTeX Font Warning: Font shape `OML/cmm/m/it' in size <9.5> not available
48     (Font)              size <9> substituted on input line 19.
49
50
51     LaTeX Font Warning: Font shape `OMS/cmsy/m/n' in size <9.5> not available
52     (Font)              size <9> substituted on input line 19.
53
54     LaTeX Font Info:    External font `cmex10' loaded for size
55     (Font)              <9.5> on input line 19.
56     LaTeX Font Info:    External font `cmex10' loaded for size
57     (Font)              <6.64996> on input line 19.
```

```
LaTeX Font Info:     External font `cmex10' loaded for size
(Font)               <4.75> on input line 19.

LaTeX Font Warning: Font shape `OT1/cmss/m/n' in size <9.5> not available
(Font)              size <9> substituted on input line 19.

\c__siunitx_mathtt_int=\count169

LaTeX Font Warning: Font shape `OT1/cmtt/m/n' in size <9.5> not available
(Font)              size <9> substituted on input line 19.

SVJour3 warning: Missing \date

LaTeX Font Warning: Font shape `OT1/cmr/bx/n' in size <9.5> not available
(Font)              size <9> substituted on input line 28.


Overfull \hbox (6.97409pt too wide) detected at line 28
|[] |
 []



LaTeX Font Warning: Font shape `OT1/cmr/bx/n' in size <13> not available
(Font)              size <12> substituted on input line 28.

LaTeX Font Info:     External font `cmex10' loaded for size
(Font)               <8> on input line 28.
LaTeX Font Info:     External font `cmex10' loaded for size
(Font)               <6> on input line 28.
LaTeX Font Info:     External font `cmex10' loaded for size
(Font)               <5> on input line 28.

Package natbib Warning: Citation `4796924' on page 1 undefined on input
line 39
.

[1{c:/TeXLive/2015/texmf-var/fonts/map/pdftex/updmap/pdftex.map}]

Package natbib Warning: Citation `RSSI_Analysis' on page 2 undefined on
input l
ine 41.


Package natbib Warning: Citation `Analysis_RSSI' on page 2 undefined on
input l
ine 41.


Package natbib Warning: Citation `kaemarungsi2012analysis' on page 2
undefined
on input line 41.
```

Package natbib Warning: Citation `zhang15' on page 2 undefined on input
line 41
.

Package natbib Warning: Citation `4796924' on page 2 undefined on input
line 41
.

Package natbib Warning: Citation `Hossain20151' on page 2 undefined on
input li
ne 41.

Package natbib Warning: Citation `ekahau' on page 2 undefined on input
line 41.

Package natbib Warning: Citation `4343996' on page 2 undefined on input
line 41
.

Package natbib Warning: Citation `4796924' on page 2 undefined on input
line 41
.

Package natbib Warning: Citation `4796924' on page 2 undefined on input
line 41
.

Package natbib Warning: Citation `yang2009indoor' on page 2 undefined on
input
line 43.

Package natbib Warning: Citation `soorty2015finding' on page 2 undefined
on inp
ut line 45.

Package natbib Warning: Citation `chandrasekaran2015inplace' on page 2
undefine
d on input line 45.

<Intro_1.jpeg, id=12, 591.71063pt x 269.50688pt>
File: Intro_1.jpeg Graphic file (type jpg)
<use Intro_1.jpeg>
Package pdftex.def Info: Intro_1.jpeg used on input line 51.
(pdftex.def)   Requested size: 284.53252pt x 113.81306pt.

[2]

Package natbib Warning: Citation `barshan1992bat' on page 3 undefined on
input
line 62.

Package natbib Warning: Citation `priyantha2000cricket' on page 3
undefined on
input line 62.

Package natbib Warning: Citation `want1992active' on page 3 undefined on
input
line 62.

Package natbib Warning: Citation `ni2004landmarc' on page 3 undefined on
input
line 62.

Package natbib Warning: Citation `hightower2000spoton' on page 3
undefined on i
nput line 62.

Package natbib Warning: Citation `ni2004landmarc' on page 3 undefined on
input
line 62.

Package natbib Warning: Citation `kaemarungsi2012analysis' on page 3
undefined
on input line 62.

Package natbib Warning: Citation `zhang15' on page 3 undefined on input
line 62
.

Package natbib Warning: Citation `ekahau' on page 3 undefined on input
line 62.

Package natbib Warning: Citation `4796924' on page 3 undefined on input
line 62
.

Package natbib Warning: Citation `Hossain20151' on page 3 undefined on
input li

ne 62.

Package natbib Warning: Citation `4796924' on page 3 undefined on input
line 63
.

Package natbib Warning: Citation `ledlie2012mole' on page 3 undefined on
input
line 63.

Package natbib Warning: Citation `yin2008LEMT' on page 3 undefined on
input lin
e 63.

Package natbib Warning: Citation `krishnan2014robust' on page 3 undefined
on in
put line 63.

Package natbib Warning: Citation `li2012Intertial1' on page 3 undefined
on inpu
t line 65.

Package natbib Warning: Citation `qian2013Intertial2' on page 3 undefined
on in
put line 65.

Package natbib Warning: Citation `farid2013recent' on page 3 undefined on
input
 line 65.

Package natbib Warning: Citation `TOA' on page 3 undefined on input line
65.

Package natbib Warning: Citation `AOA' on page 3 undefined on input line
65.

Package natbib Warning: Citation `roxin2007survey' on page 3 undefined on
input
 line 65.

Package natbib Warning: Citation `Xiao:2016:SWI:2966278.2933232' on page
3 unde
fined on input line 65.

[3 <./Intro_1.jpeg>]
Missing character: There is no â in font cmr9!
Missing character: There is no € in font cmr9!
Missing character: There is no ™ in font cmr9!

Package natbib Warning: Citation `RSSI_Analysis' on page 4 undefined on
input l
ine 67.

Package natbib Warning: Citation `Analysis_RSSI' on page 4 undefined on
input l
ine 67.

Package natbib Warning: Citation `DCE' on page 4 undefined on input line
68.

Package natbib Warning: Citation `5066966' on page 4 undefined on input
line 69
.

<environment1.jpg, id=20, 619.56468pt x 229.60782pt>
File: environment1.jpg Graphic file (type jpg)
<use environment1.jpg>
Package pdftex.def Info: environment1.jpg used on input line 75.
(pdftex.def)   Requested size: 298.74901pt x 113.81212pt.
<temp.PNG, id=21, 780.66656pt x 632.3625pt>
File: temp.PNG Graphic file (type png)
<use temp.PNG>
Package pdftex.def Info: temp.PNG used on input line 82.
(pdftex.def)   Requested size: 298.75288pt x 199.16629pt.
[4 <./environment1.jpg>]

Package natbib Warning: Citation `shanmugaapriyan2014pragmatic' on page 5
undef
ined on input line 93.

Package natbib Warning: Citation `kaemarungsi2012analysis' on page 5
undefined
on input line 93.

Package natbib Warning: Citation `CiscoLocation' on page 5 undefined on
input l
ine 93.

Package natbib Warning: Citation `shanmugaapriyan2014pragmatic' on page 5
undef
ined on input line 93.

Package natbib Warning: Citation `shanmugaapriyan2014pragmatic' on page 5
undef
ined on input line 95.

Package natbib Warning: Citation `seybold2005introduction' on page 5
undefined
on input line 97.

Package natbib Warning: Citation `sarkar2003survey' on page 5 undefined
on inpu
t line 98.

Package natbib Warning: Citation `soorty2015finding' on page 5 undefined
on inp
ut line 98.

Package natbib Warning: Citation `sarkar2003survey' on page 5 undefined
on inpu
t line 98.

Package natbib Warning: Citation `soorty2015finding' on page 5 undefined
on inp
ut line 98.

[5 <./temp.PNG>]

Package natbib Warning: Citation `srinivasa2009path' on page 6 undefined
on inp
ut line 105.

[6] <Two-Intersect.jpg, id=36, 301.125pt x 258.9675pt>
File: Two-Intersect.jpg Graphic file (type jpg)
<use Two-Intersect.jpg>
Package pdftex.def Info: Two-Intersect.jpg used on input line 138.
(pdftex.def)   Requested size: 97.16145pt x 79.6666pt.
<In-Between.jpg, id=37, 301.125pt x 258.9675pt>
File: In-Between.jpg Graphic file (type jpg)
<use In-Between.jpg>
Package pdftex.def Info: In-Between.jpg used on input line 140.
(pdftex.def)   Requested size: 97.16145pt x 79.6666pt.
<Non-Intersect.jpg, id=38, 301.125pt x 258.9675pt>
File: Non-Intersect.jpg Graphic file (type jpg)
<use Non-Intersect.jpg>
Package pdftex.def Info: Non-Intersect.jpg used on input line 142.
(pdftex.def)   Requested size: 97.16145pt x 79.6666pt.

Underfull \hbox (badness 10000) in paragraph at lines 128--153

```
  []

[7 <./Two-Intersect.jpg> <./In-Between.jpg> <./Non-Intersect.jpg>]
<Anomalous_C
entroid_Edited.jpg, id=43, 572.89032pt x 280.79906pt>
File: Anomalous_Centroid_Edited.jpg Graphic file (type jpg)
<use Anomalous_Centroid_Edited.jpg>
Package pdftex.def Info: Anomalous_Centroid_Edited.jpg used on input line
169.
(pdftex.def)              Requested size: 312.9803pt x 153.40735pt.
<Skewed_Centroid.jpg, id=44, 569.87906pt x 267.24844pt>
File: Skewed_Centroid.jpg Graphic file (type jpg)
<use Skewed_Centroid.jpg>
Package pdftex.def Info: Skewed_Centroid.jpg used on input line 177.
(pdftex.def)              Requested size: 312.9803pt x 146.77097pt.
[8 <./Anomalous_Centroid_Edited.jpg>]
Underfull \vbox (badness 1668) has occurred while \output is active []

[9 <./Skewed_Centroid.jpg>]

Package natbib Warning: Citation `chandrasekaran2015inplace' on page 10
undefin
ed on input line 215.

[10] [11] [12]

LaTeX Warning: File `comparisoncase.jpg' not found on input line 341.


! Package pdftex.def Error: File `comparisoncase.jpg' not found.

See the pdftex.def package documentation for explanation.
Type  H <return>  for immediate help.
 ...

l.341 ...graphics[width=115mm]{comparisoncase.jpg}

Using draft setting for this image.
Try typing  <return>  to proceed.
If that doesn't work, type  X <return>  to quit.


Package natbib Warning: Citation `DCE' on page 13 undefined on input line
355.

[13]
Underfull \vbox (badness 10000) has occurred while \output is active []

[14]

LaTeX Font Warning: Font shape `OT1/cmr/m/it' in size <9.5> not available
(Font)              size <9> substituted on input line 397.
```

```
LaTeX Font Warning: Font shape `OT1/cmr/bx/it' in size <9.5> not
available
(Font)                size <9> substituted on input line 397.


[15]
LaTeX Font Info:    Try loading font information for OML+cmr on input
line 443.


(c:/TeXLive/2015/texmf-dist/tex/latex/base/omlcmr.fd
File: omlcmr.fd 2014/09/29 v2.5h Standard LaTeX font definitions
)
LaTeX Font Info:    Font shape `OML/cmr/m/n' in size <8> not available
(Font)                Font shape `OML/cmm/m/it' tried instead on input line
443.
[16] [17]
No file wifidoc.bbl.

Package natbib Warning: There were undefined citations.


[18] (./wifidoc.aux)


LaTeX Font Warning: Size substitutions with differences
(Font)                up to 1.0pt have occurred.


 )
(\end occurred inside a group at level 1)


### simple group (level 1) entered at line 1061 ({)
### bottom level
Here is how much of TeX's memory you used:
 13111 strings out of 493027
 264145 string characters out of 6137679
 297630 words of memory out of 5000000
 16553 multiletter control sequences out of 15000+600000
 12278 words of font info for 44 fonts, out of 8000000 for 9000
 1141 hyphenation exceptions out of 8191
 38i,21n,42p,10381b,3632s stack positions out of
5000i,500n,10000p,200000b,80000s
<c:/TeXLive/2015/texmf-dist/fonts/type1/public/amsfonts/cm/cmbx
12.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmbx8.pfb><c:
/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmbx9.pfb><c:/TeXLive/2
015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmbxti10.pfb><c:/TeXLive/2015/tex
mf-dist/fonts/type1/public/amsfonts/cm/cmex10.pfb><c:/TeXLive/2015/texmf-
dist/f
onts/type1/public/amsfonts/cm/cmmi5.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1
/public/amsfonts/cm/cmmi6.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/am
sfonts/cm/cmmi7.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/
```

```
cmmi8.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmmi9.pfb>
<c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmr6.pfb><c:/TeXLive
/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmr8.pfb><c:/TeXLive/2015/texmf
-dist/fonts/type1/public/amsfonts/cm/cmr9.pfb><c:/TeXLive/2015/texmf-
dist/fonts
/type1/public/amsfonts/cm/cmsy6.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/pub
lic/amsfonts/cm/cmsy7.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfon
ts/cm/cmsy8.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmsy
9.pfb><c:/TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmti8.pfb><c:/
TeXLive/2015/texmf-
dist/fonts/type1/public/amsfonts/cm/cmti9.pfb><c:/TeXLive/20
15/texmf-dist/fonts/type1/public/amsfonts/cm/cmtt8.pfb>
Output written on wifidoc.pdf (18 pages, 547255 bytes).
PDF statistics:
 153 PDF objects out of 1000 (max. 8388607)
 102 compressed objects within 2 object streams
 0 named destinations out of 1000 (max. 500000)
 41 words of extra memory for PDF output out of 10000 (max. 10000000)
```

Original Case   Radii re-estimated by DCE   Radii re-estimated by WALE

X Estimated Point   ● Actual Point