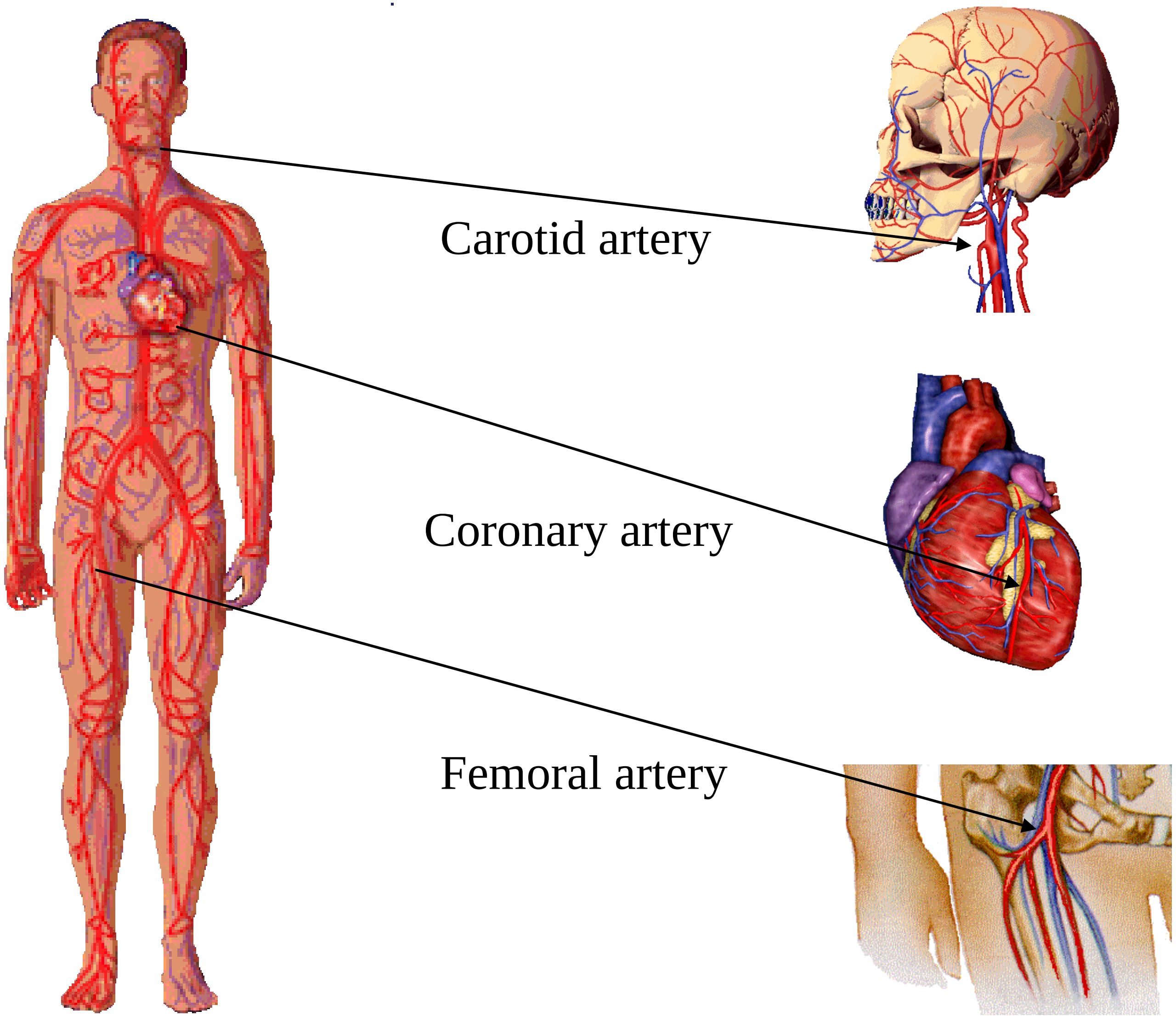
Automated Ultrasonic Measurement of Human Arteries

Tomas Gustavsson

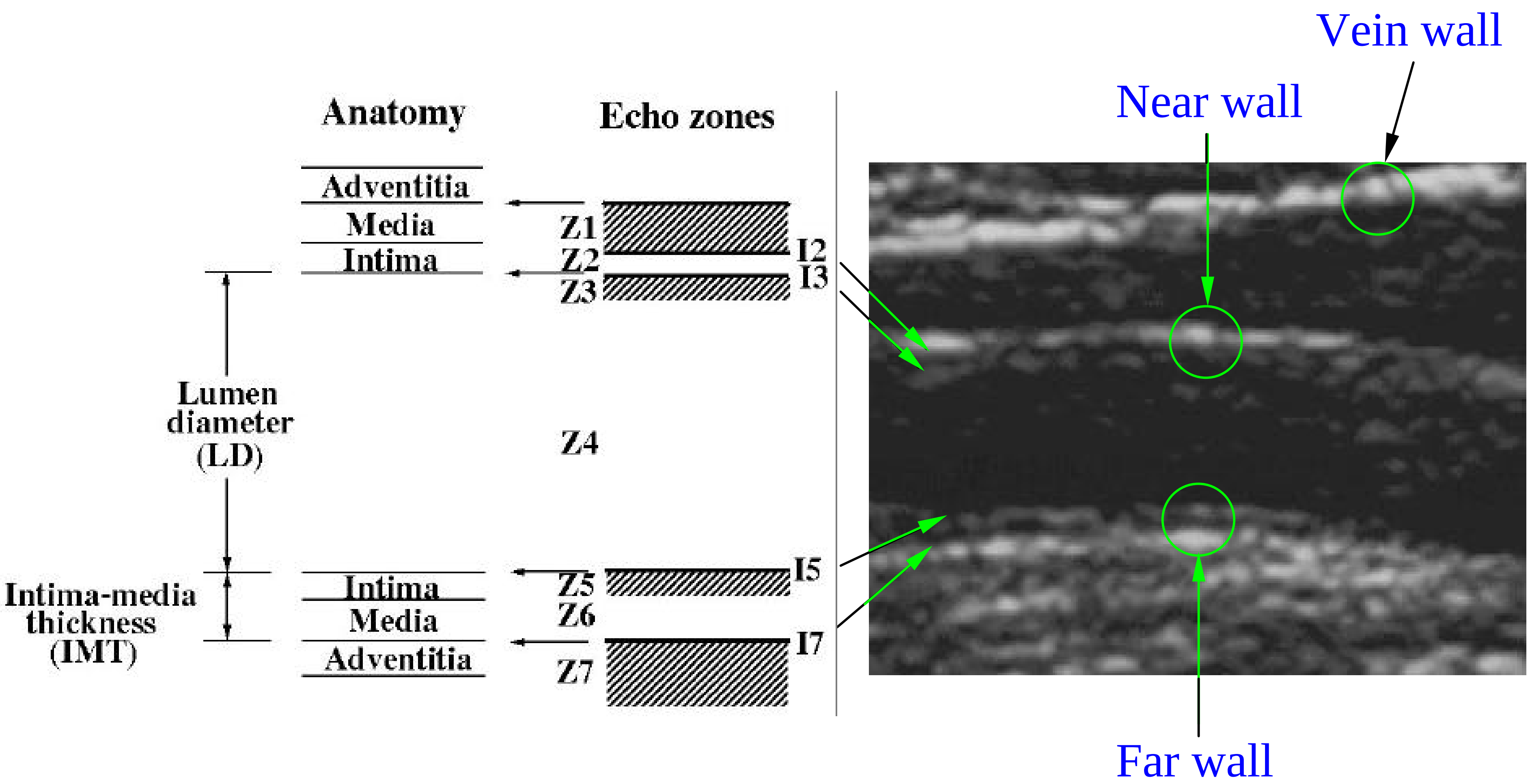
1. Introduction



The Artery Tree

Ultrasound carotid artery examination

Ultrasound artery analyzing

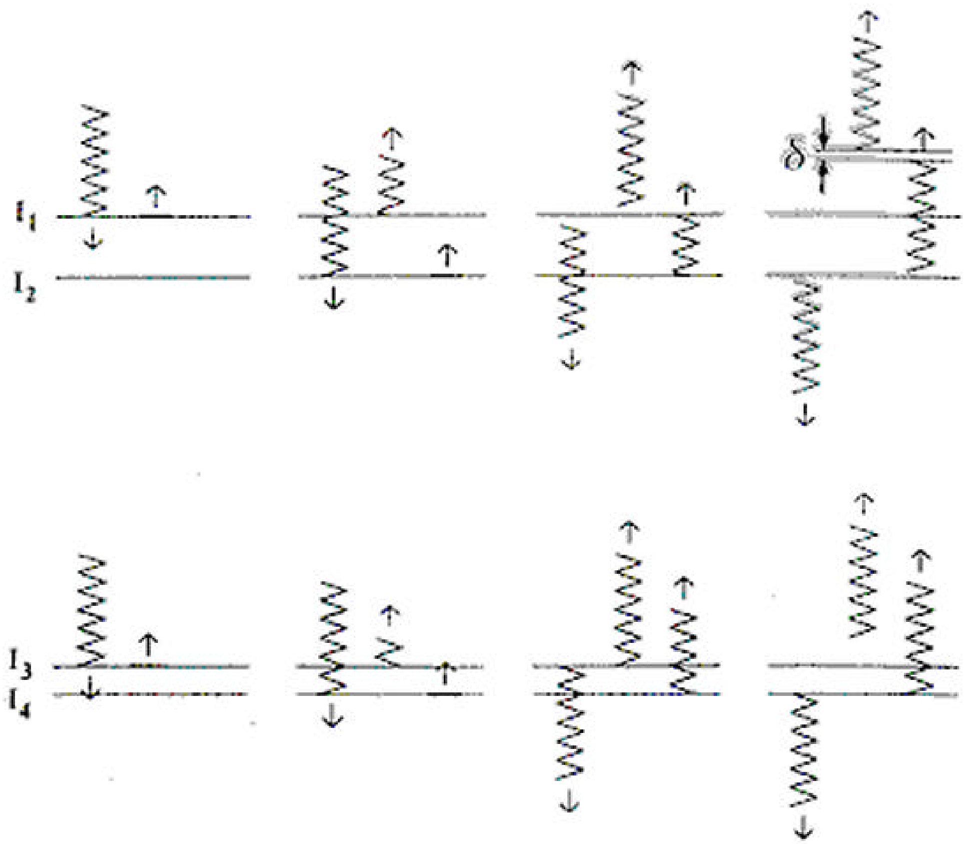


Mapping of echo image to anatomic structure of artery

Theoretical maximum of resolution

$T=T_1$ $T=T_2$ $T=T_3$ $T=T_4$

$P_T\ E_1$ $P_T\ E_1\ E_2$ $P_T\ E_1\ E_2$ $P_T\ E_1\ E_2$



Theoretical maximum of resolution

The wavelength of the ultrasonic pulse is given by:

$$\lambda = c/f$$

Where c is the speed of sound in biological tissue and f is the transducer frequency. The pulse length is approximatively:

$$lp = n \times \lambda$$

where n is the number of cycles that are used to produce the ultrasonic pulse.

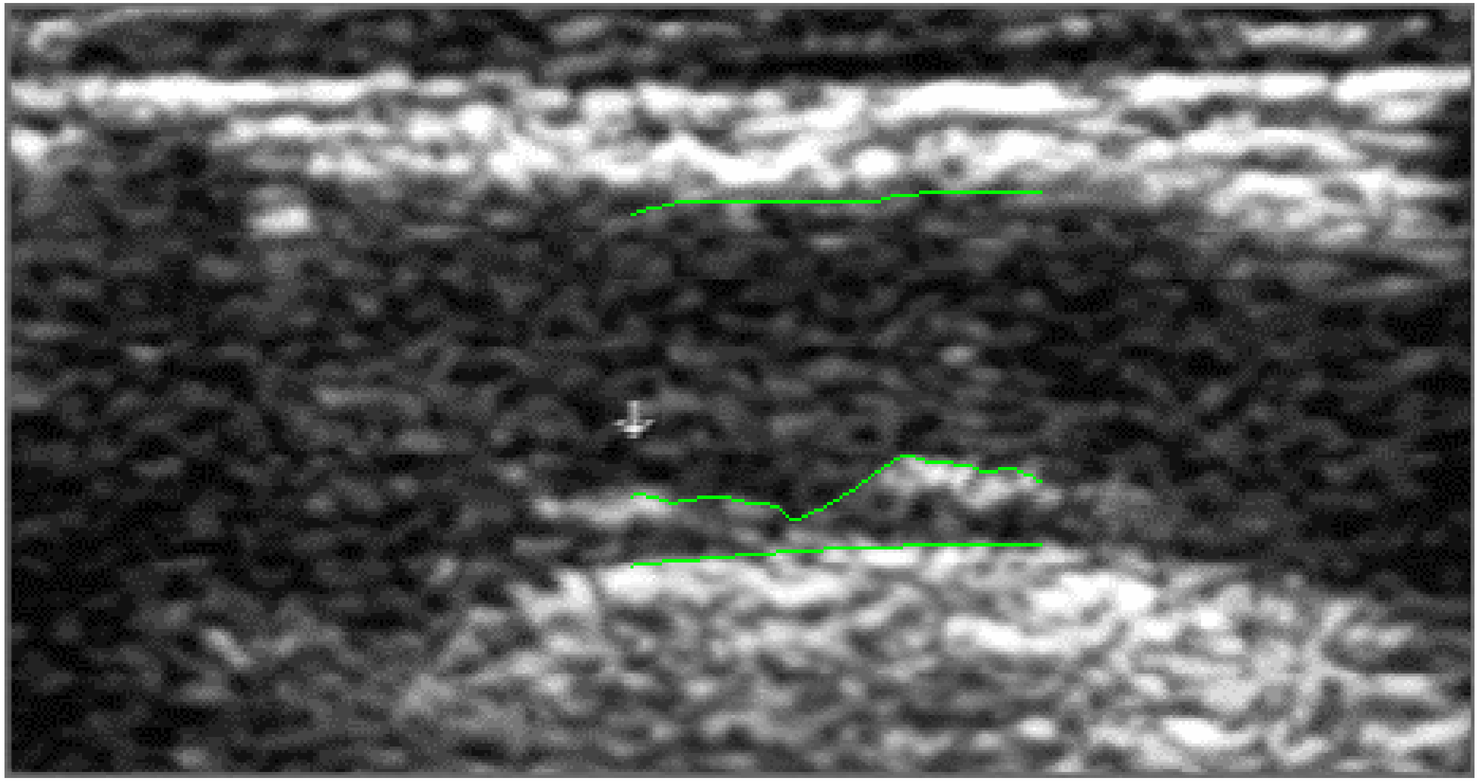
Theoretical maximum of resolution

The minimum thickness of a resoluble structure is: $d = lp/2$

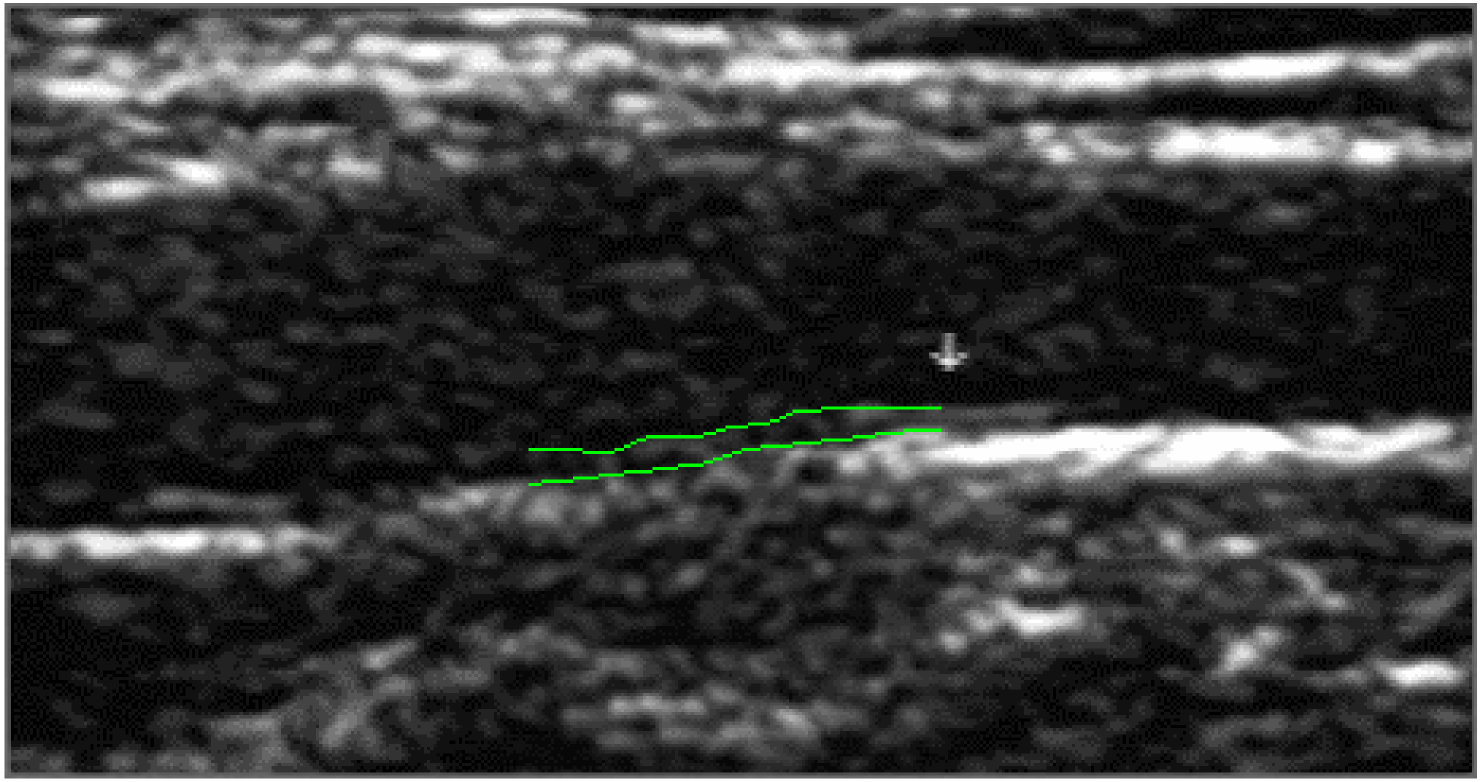
Combining these equations yields:

$$d = \frac{n \times c}{2 \times f}$$

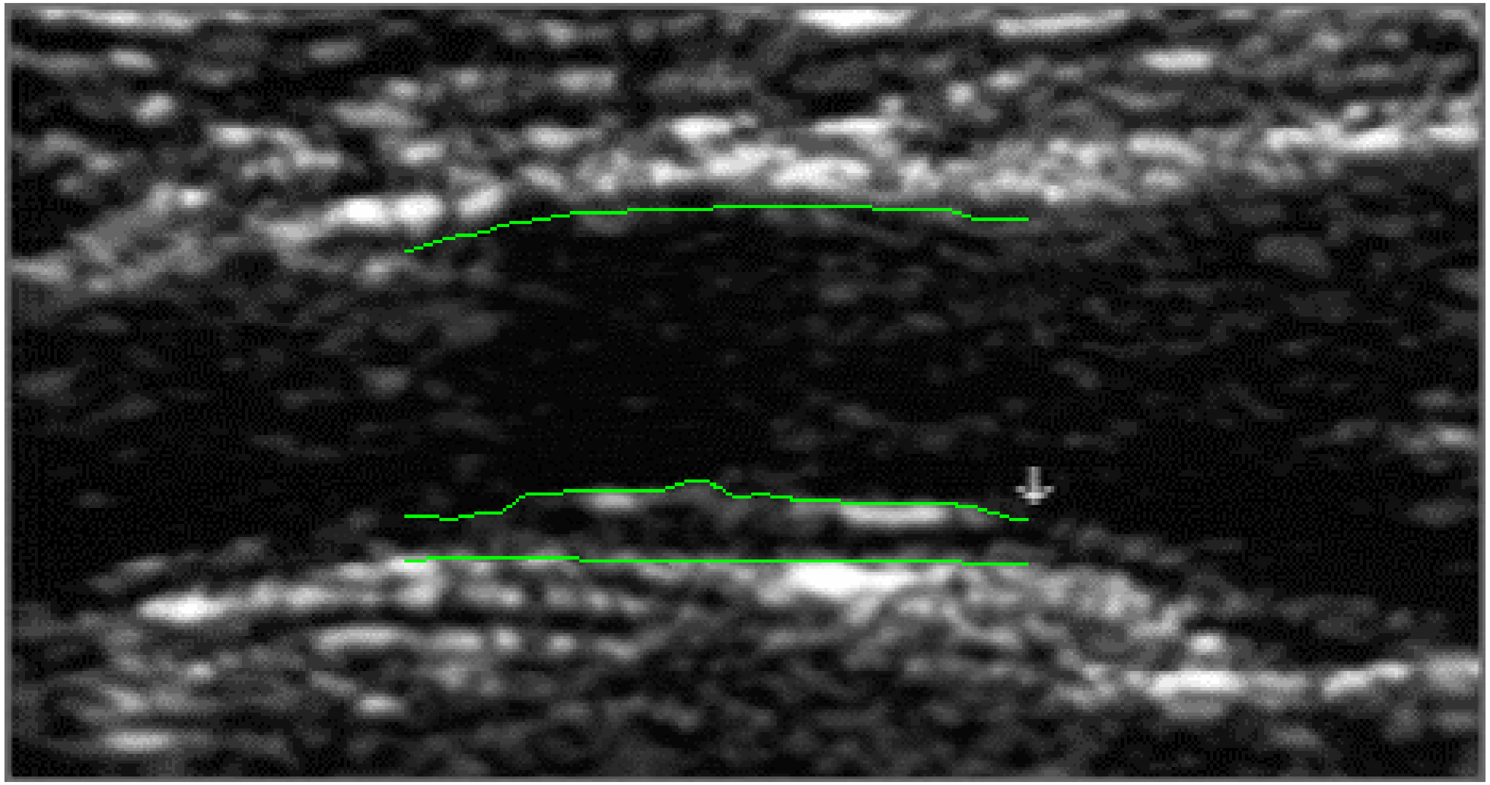
In a typical case with $n=3$, $c=1.5x10^3\ m.s^{-1}$ and $f=7Mhz$, say, one finds that: $d=0.3\ mm$



Example of detection result — Common carotid artery



Example of detection result — Carotid artery bulb



Example of detection result — Common femoral artery

Evaluation in clinical application environment

(The evaluation result has been published in ***Stroke***, Vol.28 1997 Nov.)

- Subjects: New, n = 50.
- Images: 9 images from each subject.

  (3 CCA, 3 Bulb, 3 CFA)
- Operators: Three operators with different experiences,

  Independent evaluation.
- Method: Manual vs. Automated.

3. Result

Table 1. Comparison between manual and automated analysing systems

	Manual system *Mean*±*SD* (mm)	Automated system *Mean*±*SD* (mm)	Difference between systems (mm)	*CV* (%)	Correlation (*r*)
Common carotid artery (n=50)					
IMT_{mean}	0.88±0.25	0.92±0.25	0.042***	2.0	1.00
IMT_{max}	1.05±0.32	1.12±0.32	0.078***	4.1	0.98
LD_{mean}	6.18±0.73	6.24±0.75	0.063***	1.6	0.98
Carotid artery bulb (n=45)					
IMT_{mean}	1.03±0.34	1.04±0.31	0.019*	4.7	0.98
IMT_{max}	1.39±0.51	1.48±0.53	0.088***	4.9	0.98
Common femoral artery (n=45)					
IMT_{mean}	1.25±0.65	1.25±0.64	-0.003	4.3	0.99
IMT_{max}	1.65±0.90	1.69±0.90	0.042*	5.4	0.99
LD_{mean} (n=38)	8.22±1.39	8.34±1.43	0.116***	1.3	0.99

SD : standard deviation.

* $p < 0.05$, *** $p < 0.001$ for differences between analyzing systems.

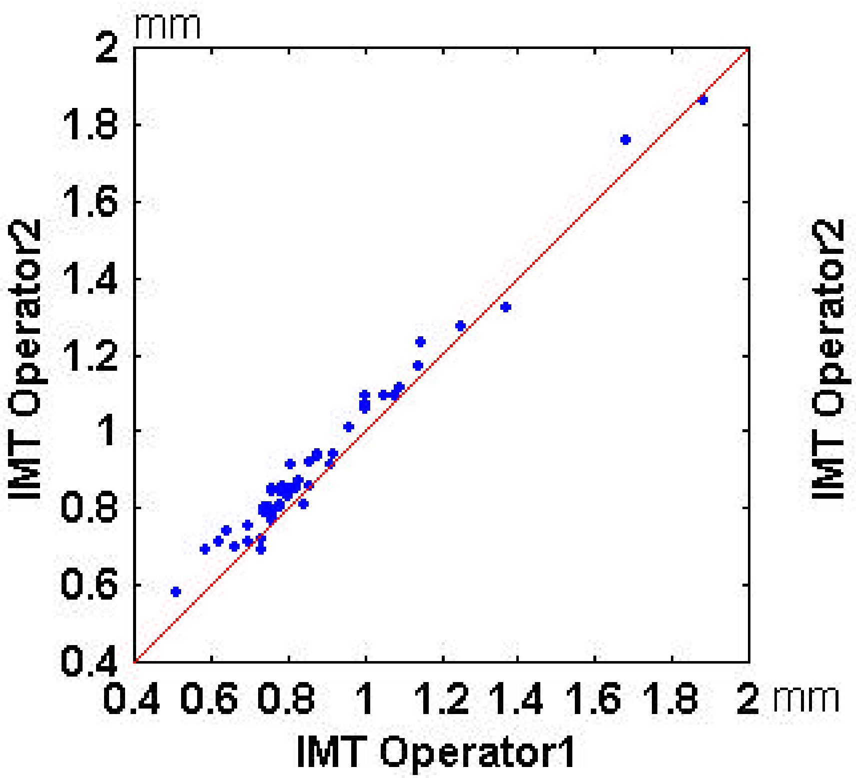
3. Result

Table 2. Reading variability when measurements were performed with the manual analysis system and with the automated analyzing system, respectively.

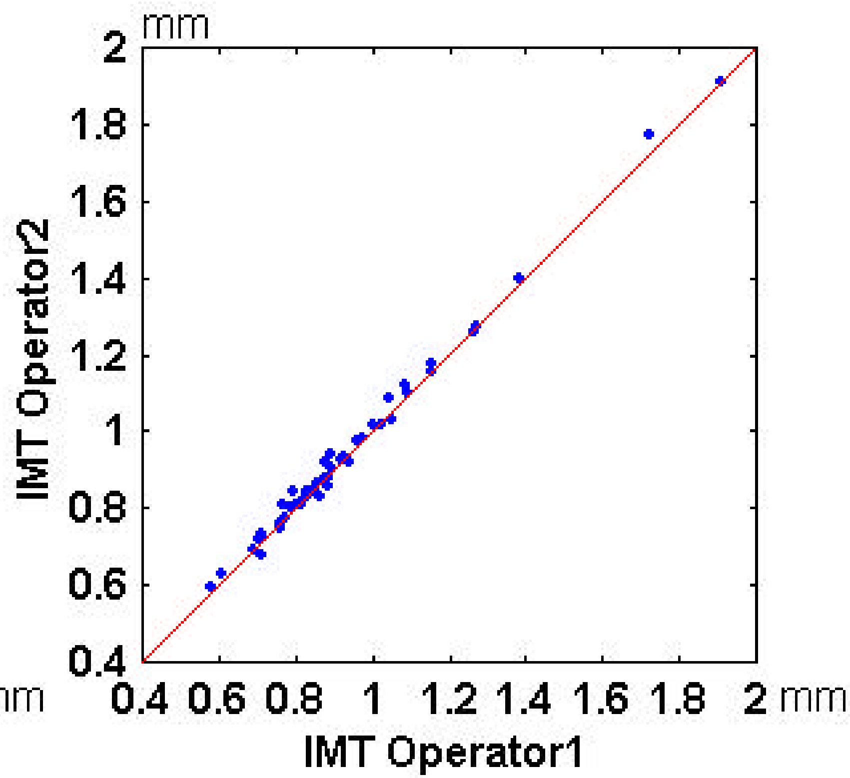
	Manual system				Automated system			
	Reader 1 *Mean±SD* (mm)	Reader 2 *Mean±SD* (mm)	Difference btw. readers (mm)	*CV* (%)	Reader 1 *Mean±SD* (mm)	Reader 2 *Mean±SD* (mm)	Difference btw. readers (mm)	*CV* (%)
Common carotid artery (n=50)								
IMT_{mean}	0.88±0.25	0.92±0.24	0.040***	2.8	0.93±0.25	0.93±0.25*	0.007	1.4
IMT_{max}	1.05±0.32	1.09±0.30	0.042***	4.1	1.12±0.32	1.13±0.31	0.005	2.2
LD_{mean}	6.18±0.75	6.23±0.76	0.045***	1.7	6.24±0.76	6.25±0.76**	0.014	0.3

SD : Standard Deviation.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ for difference between readers



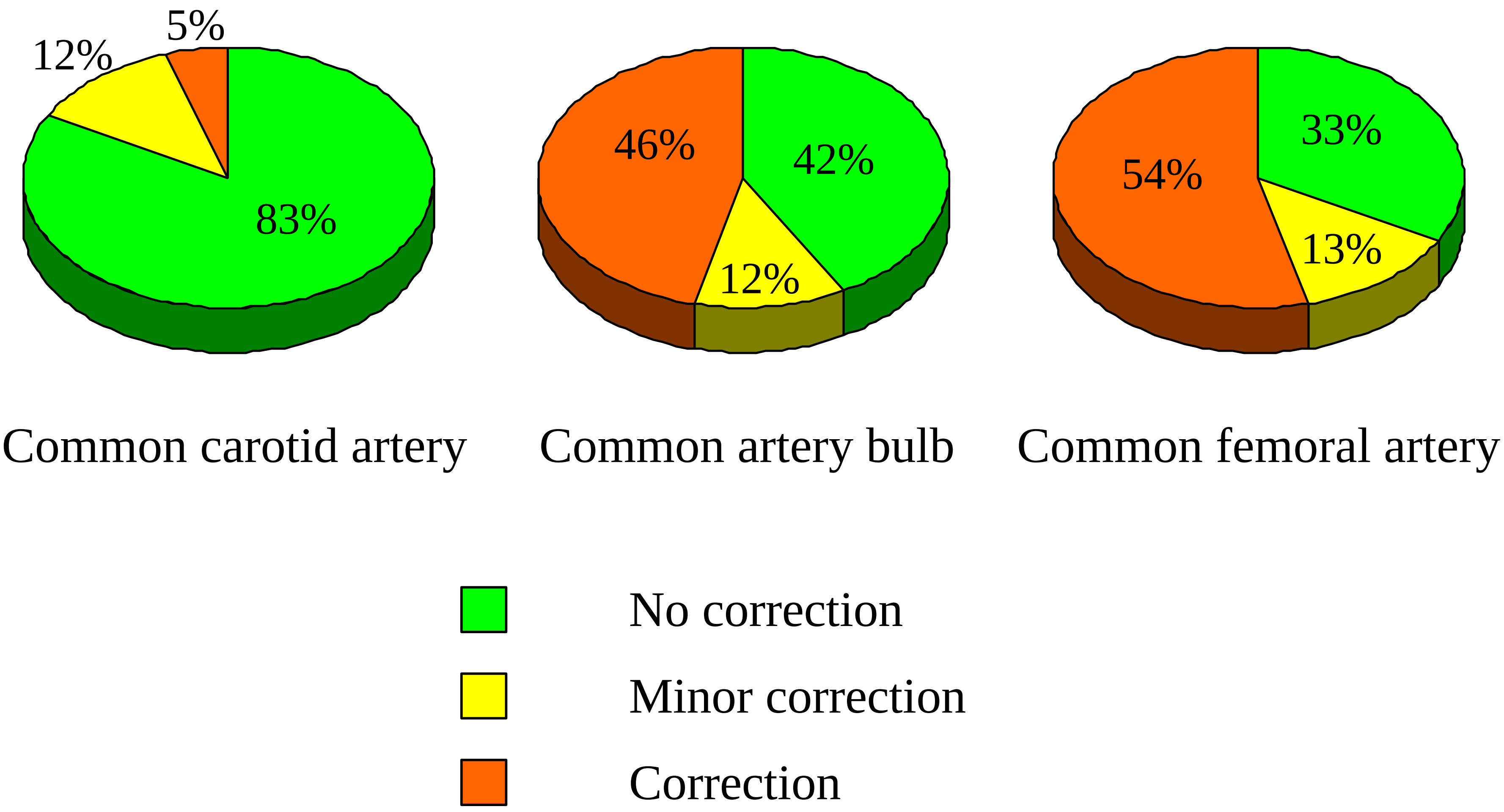
(a) Manual system



(b) Automated system

Variability between two experienced readers

3. Result



Correction needed

3. Result

Complete analysis

Pure analysis

Manual system

Automated system

Time needed for analyzing images from one patient (9 images)

Conclusion

The automated artery measurement method
can replace the previous manual method

with

reduced inter- and intra-observer variability
and fast process speed.


End