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USS3

USS3

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RMSE

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RMSE

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. (Shariati, 2004)

( ) Cho & Ki

hmasoodi@ut.ac.ir :

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( ) Shin & Kim

( )

( ) Singh et al. .

: (Seidi, 2005)

/ / /

Karparvar .

( ) Bayati ( ) Fard

( ) Alimardani et al. .

Seidi .

( )

( ) Aghkhani & Abbaspour Fard .

.(Tillett, 1991)

- 
- 1. Dead Reckoning
  - 2. Machine Vision
  - 3. Global Positioning System(GPS)
  - 4. Orientation
  - 5. Position

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(Barawid et al., 2007) ( )

$$\varphi = (\theta + \tan^{-1}(\frac{e}{l})) \rightarrow \alpha = \tan^{-1}(\frac{e}{l}) \ \& \ \phi = -(\theta + \alpha)$$

$\theta$  ( )  $\phi$

1 ( )  $e$  ( )

$$(V_R) \quad (V_L) \quad (V_{R,L} \propto f(\phi))$$

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( ) Best Technology USS3

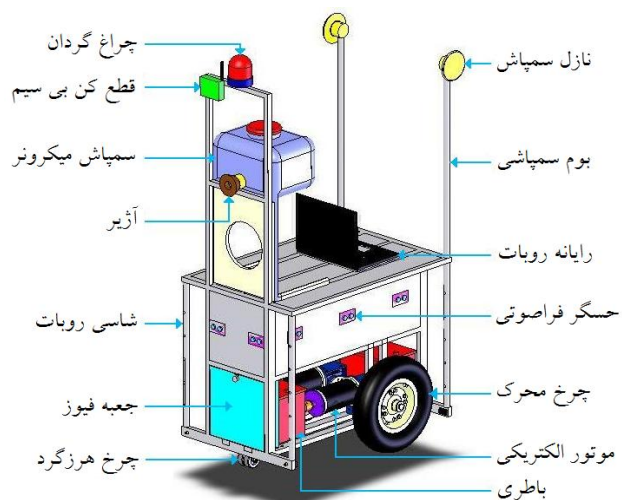
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Archive of SID

(Gray, ( CCD ) (2000)



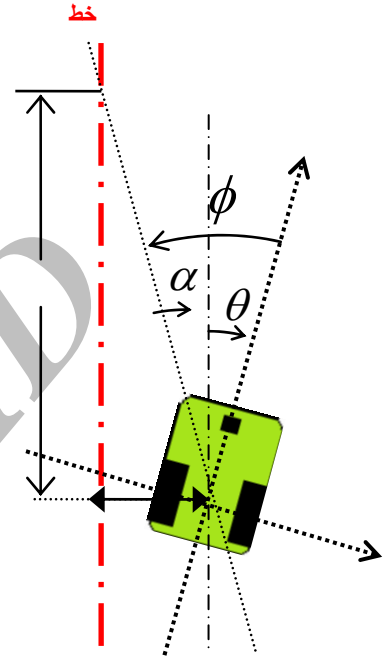
3. Steering angle
4. Look ahead distance
5. Sonar

1. Mobile Robot
2. Ultrasonic Range Finder

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( )

( )



(e)

(θ)

( )

(Barawid et al., 2007)( )

Vehicle Robotics

USS3



USS3

USS3

(Best Technology Company, 2008)

1. USS3 Configurator

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C++

Visual Studio 2008

(Disto pro4a, Leica Geosystems Co.)

13. Axial laser range finder

USS3

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RS485

14. Response frequency  
15. Digital packet

C++

( )

Visual Studio 2008

USS3

USS3

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USB

x

x

( )

( )

Solid Works

2003

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JG-35FD

17. Fiber optic gyroscope(FOG)

16. Detection area

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(RMSE)

( )

$$RMSE = \sqrt{\frac{\sum_{i=1}^n e_i^2}{n}}$$

e

)

n (

( )

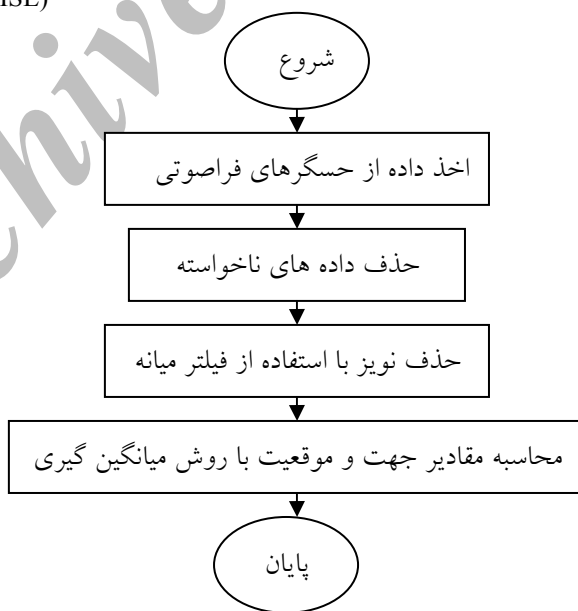
(Cho & Ki, 1999; Singh et al., 2005)

19. Median filter

20. Averaging method

21. Root Mean Square Error (RMSE)

18. Robotic total station



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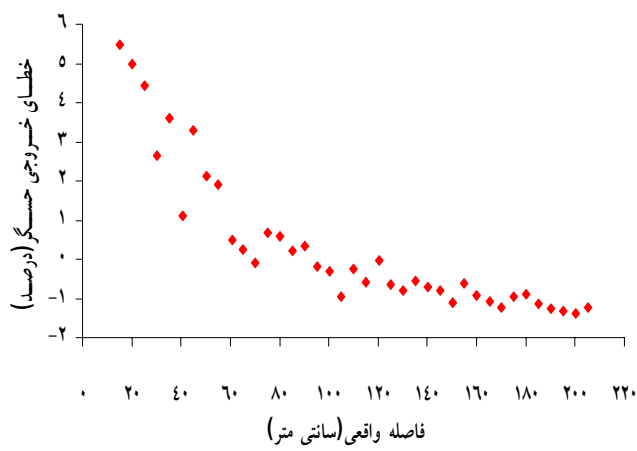
+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+
		+	+	+	+	+	+	+		
			+	+	+	+	+	+		
							+	+	+	

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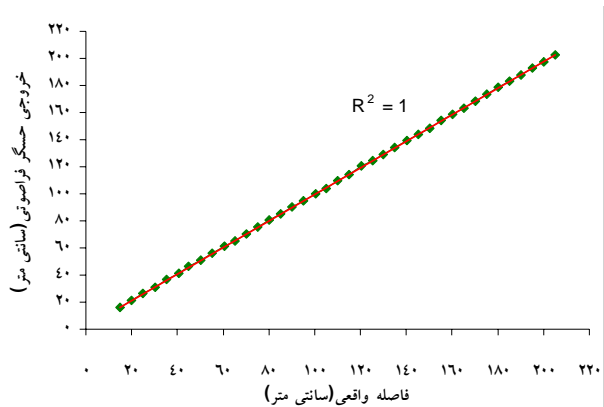
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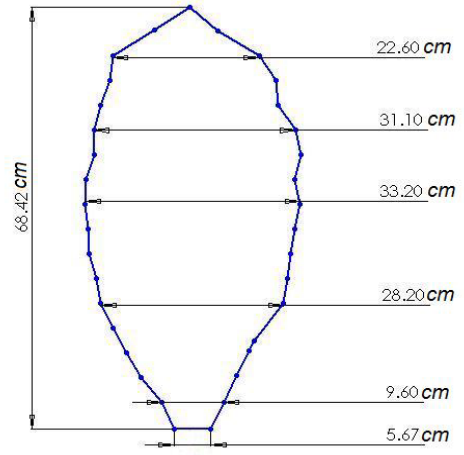
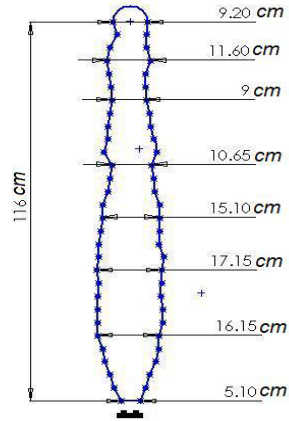


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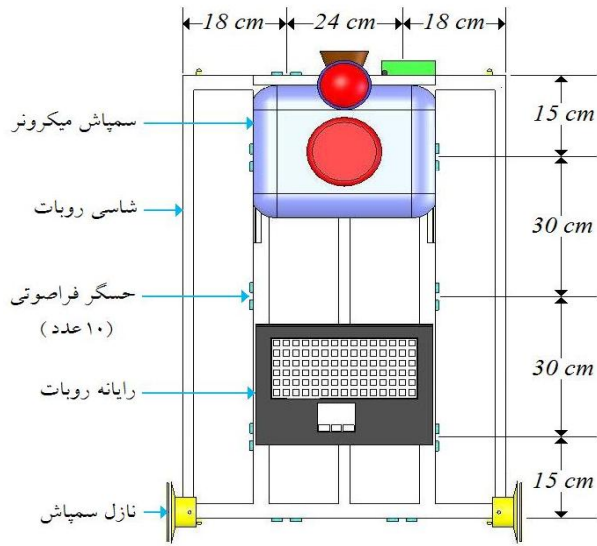
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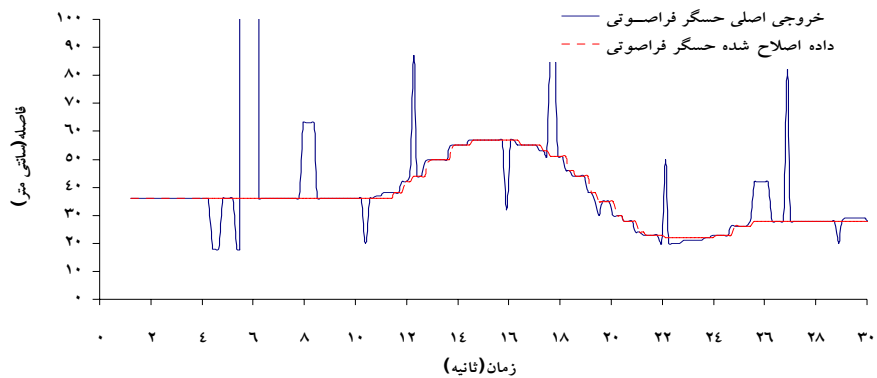
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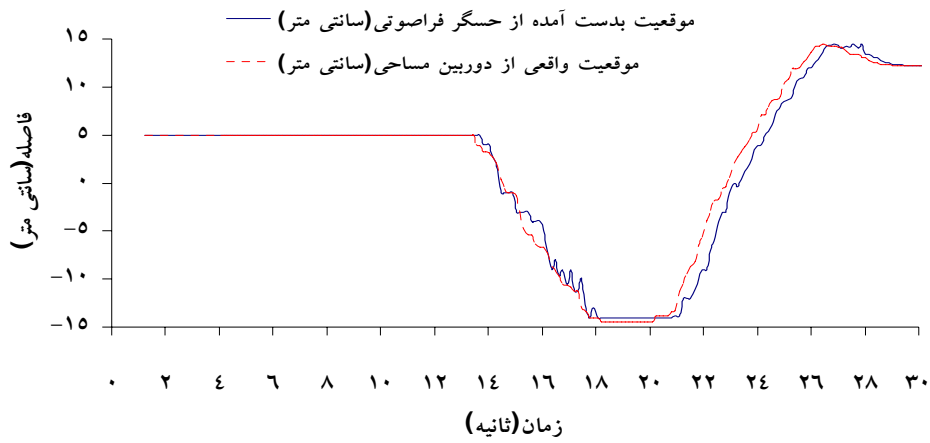


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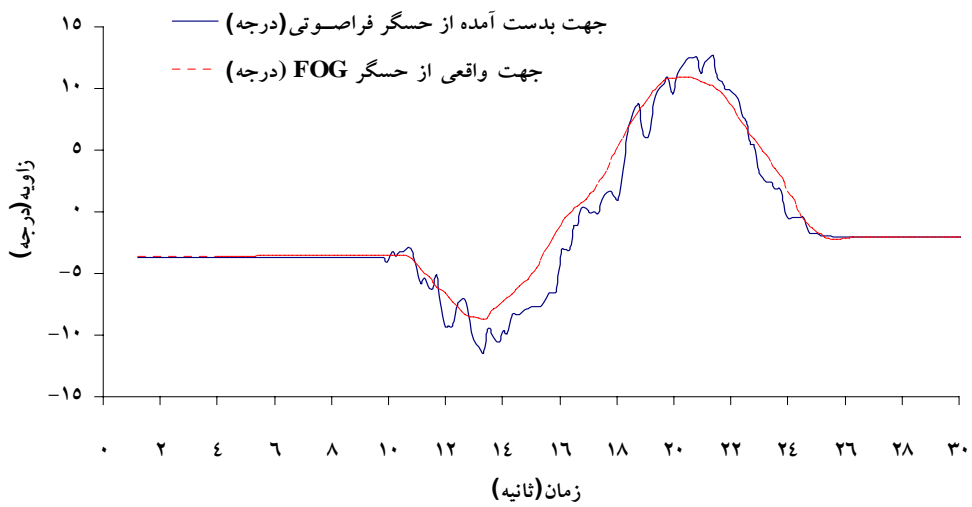
( ) Singh et al.

RMSE / RMSE ( ) Singh et al. / RMSE



FOG

FOG  
RMSE



( )

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( IMU<sup>22</sup>

## Vehicle Robotics

USS3

cm	e
cm	l
-	n
cm	RMSE
V	$V_L$
V	$V_R$
deg	$\phi$
deg	$\theta$

## 22. Inertial Measurement Unit

## REFERENCES

- Aghkhani, M. H. & Abbaspour Fard, M. H. (2009). Automatic off-road vehicle steering system with a surface laid cable: Concept and preliminary tests. *Biosystems Engineering*, 103(1), 265 – 270.
- Alimardani, R., Taher Khoramabadi, A., Oroojlou, M., & Mesgari, Sh. (1994). *Remote control garden tractor*. Project report, Department of Agricultural Machinery Engineering, Faculty of Agriculture, University of Tehran, Karaj, Iran. (In Farsi)
- Barawid, O. C., Mizusshima, A., Ishii, K. & Noguchi N. (2007). Development of an autonomous navigation system using a two-dimensional laser scanner in an orchard application. *Biosystems Engineering*, 96(2), 139-149.
- Bayati, M. R. (1994). *Design, construction and performance evaluation of self leveling system on a tractor*. M. Sc. thesis, Agricultural Machinery Engineering Division, Faculty of Agriculture, Shiraz University, Shiraz, Iran. (In Farsi)
- Best Technology Company. (2008). *USS3 Ultrasonic Sensor*. Retrieved May 20, 2008, from <http://www.besttechnology.co.jp>.
- Cho, S. I. & Ki, N. H. (1999). Autonomous speed sprayer using machine vision and fuzzy logic. *Transactions of the ASAE*, 42(40), 1137-1143.
- Gray, K. W. (2000). *Obstacle detection and avoidance for an autonomous farm tractor*. M. Sc. Thesis, Utah State University, Logan, Utah, USA.
- Karparvar Fard, H. (1990). *Design, construction and evaluation of a self leveling system on a tractor*. M. Sc. Thesis, Department of Agricultural Machinery Engineering, Faculty of Agriculture, Tarbiat Modarres University, Tehran, Iran. (In Farsi)
- Seidi, E. (2005). *Evaluation of using from automatic steering system on common tractors in Iran with appropriate technology*. M. Sc. Thesis, Department of Agricultural Machinery Engineering, Faculty of Agriculture, University of Tabriz, Tabriz, Iran. (In Farsi)
- Shariati, S. I. (2004). *Design and fabrication of a prototype manipulator for fruits detection in a special direction*. M. Sc. Thesis, Department of

...

:

Agricultural Machinery Engineering, Faculty of agriculture, University of Tehran, Karaj, Iran. (In Farsi)

Shin, B. & Kim, S. (2001). Autonomous guidance system for small orchard sprayer with ultrasonic sensors. *ASAE Paper No. 011193*, St Joseph, MI: ASAE.

Singh, S., Burks, T. F. & Lee, W. S. (2005). Autonomous robotic vehicle development for greenhouse spraying. *Transactions of the ASAE*, 48(6), 2355–2361.

Tillett, N. D. (1991). Automatic guidance sensors for agricultural field machines: A Review. *Journal of Agricultural Engineering Research*, 50, 167-187.

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