Abstract- This paper presents the automatic steering control of farming vehicle using GPS receiver. Automatic steering devices for farming vehicles like tractors, seeding vehicle, weed control vehicle, spraying machine vehicle etc. have the task to relieve the driver from the physical and mental stress of monotonous steering work. Simultaneously, they are intended to help him to exploit machines and farming vehicle closer to their full performance and improve the quality of work. Vehicles frequently have to be steered in and exact straight line and along rows in the farm land. GPS receiver fetches the information of positions (latitude and longitude) of the farm land which needs to be cultivated. With the help of GPS and microcontroller (Arm9) we calculate the boundary of farm land, slope of straight line and angle of movement with the help of slope changes. The microcontroller generates the control signals to stepper motor for steering of vehicle.

Keywords- Automatic steering control, GPS receiver, Microcontroller, automatic guidance of vehicle, web camera, electronic compass, accelerometer.

I. INTRODUCTION

Automated guidance can greatly reduce drivers fatigue factor and effort and as a result increases both productivity and safety of farm operations. Different approaches have been studied and proposed for realizing automatic guidance for agricultural vehicle, using global positioning system. These are machine vision with GPS receiver, guidance of tractor by a four antenna real-time kinematic-GPS (RTK-GPS) [1] and carrier phase differential GPS (CDGPS) [2], guidance by geomagnetic magnetic sensor (GDS) [3] and GPS and steering control by Real-time differential carrier phase GPS aided INS [4]. The RTK-based GPS systems can compensate for atmospheric delay, orbital errors, and other variables in GPS geometry. RTK or real time kinematics GPS systems can provide sub-inch accuracy. The precision can be up to a centimeter or less. A base station sends out a corrective signal that can be used by several moving stations to arrive at accurate positions. Using precise differential carrier phase measurements of satellite signals, CDGPS-based systems have demonstrated centimeter-level accuracy in vehicle position determination [5] and 0.1° accuracy in attitude determination [6]. System integrity becomes impeccable with the addition of pseudo-satellite Integrity Beacons [7]. The ability to accurately and reliably measure multiple states makes CDGPS ideal for system identification, state estimation [8] But RTK-GPS and CDGPS are not applicable everywhere. One of the most common types of navigation sensor is the global positioning system (GPS). Which is easily available and also applicable everywhere. Therefore we used the common GPS device with electronic compass, accelerometer and web camera to automate the farming vehicle.

Commercially available GPS receivers provide 3 meters to 5 meters accuracy but with the help of coordinate geometry, accelerometer electronic compass and web camera we automated vehicle precisely and perfectly. Estimation of farming vehicle position is essential information for automatic guidance farming vehicle. Two methods are commonly used to position vehicle, namely the relative positioning method (e.g. dead reckoning) and the absolute positioning method. We used absolute positioning method, in absolute positioning method it detects references and calculate the vehicle position using the relationship between a vehicle and the reference points. GPS technology is often used for the absolute position measurement. A GPS receiver must be able to lock onto signals from at least four different satellites to compute its location in a three dimensional space. Moreover, the receiver must maintain its lock on each satellite’s signal for a period of time that is long enough to receive the information encoded in the transmission.
II. EXPERIMENTAL SETUP

In the top of the vehicle GPS receiver, Accelerometer, electronic compass and web camera were mounted. GPS receiver gives the information about position of the farming vehicle, accelerometer estimates the velocity and acceleration of the farming vehicle, electronic compass gives direction of the vehicle and web camera recognizes the obstacle in the field. Web camera also estimates the position of vehicle from crops in case of spraying and weeds control. It helps to develop machine vision algorithms that can detect crop rows in real time and the relative position and orientation of robot to the row can be used as input for tracking the crop row. Keypad is used for storing the value of boundary points of field and other input purposes. Display unit display the current position of latitude and longitude and instruction for operating the vehicle initially. Microcontroller gives the instruction to stepper motor to steering farming vehicle.

![Figure 1. Block- Diagram of automatic farming vehicle](image)

![Figure 2. Model of automatic farming vehicle](image)
An Autonomous Vehicle for Farming Using GPS

III. POSITION INFORMATION FROM GPS

GPS receiver gives the positions in the term of latitude and longitude. We obtain several sentences from GPS receiver known as GPS-NMEA sentence information. For latitude and longitude information we use GPRMC sentence.

GPRMC sentence format is [8]:
SGPRMC, hhmss.ss, A, llll.ll, a, x.x.x.x, dmmmxx, x.x,a*hh
i.e. $GPRMC,220516,A,5133.82,N,00042.24,W,173.8,231.8,130694,004.2,W*70

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
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IV. CALCULATION OF DISTANCE, SLOPE AND STRAIGHT LINE EQUATION

A. Distance Calculation-
For greater accuracy, we used the great circle distance formula. This formula requires use of spherical geometry and a high level of floating mathematical accuracy about 15 digits of accuracy. Therefore in order to use this formula properly we used higher version of controller (arm9). Arm9 microcontroller is easily capable of double-precision floating point calculations.

Great Circle Distance Formula Using Radians[9]:
R*arcos [sin (lat1)*sin (lat2) + cos (lat1)*cos (lat2)*cos (lat2-lat1)] …………….1
Where R = 6378.7 Km or 3963.0 miles.
Approximate distance in miles:
D=sqrt (x*x+ y*y)…………………………………………………………………………..2
Where x= 69.1*(lat2-lat1)…………………………………………………………………. ..3
And y= 69.1*(long2-long1)*cos (lat1/57.3)………………… …………………………...4

B. Slope calculation-
First change the latitude and longitude value in degree then change into the Cartesian Coordinates with the help of formula 3 and formula 4 and calculate slope with the help of formula

\[ m = \frac{\text{change of } y}{\text{change of } x} \]

Steering angle calculation: \( \theta = \text{arctan}\left(\frac{m2 - m1}{x}\right) \) ………………………………………………………………………….5
Where m1 and m2 are slope of the straight line 1 and 2 respectively.

C. Straight line equation-
If position of the point is \((x_1, y_1)\) and slope of the line is m then equation of the straight line is:
\[ y-y_1=m(x-x_1) \] ……………………………………………………………………………..7

D. Use of accelerometer-
We calculated accurate position of the farming vehicle with the help of accelerometer and GPS receiver. Accelerometer gives velocity and acceleration of farming vehicle and GPS receiver gives the position of farming vehicle. We calculated new positions between two consecutive positions given by GPS receiver. i.e. accelerometer helps to obtain the accurate position of the farming vehicle.

V. STEER CONTROL AND MOVEMENT OF VEHICLE

The microcontroller generates the control signals with the help of accelerometer and GPS receiver to controls the steering of vehicle. Microcontroller signal is used to control the stepper motor. Stepper motor changes the steering angle of the front or rear axle. Steering angle \( \theta \) is calculated by the change of slopes by the formula 6. For the forward movement used equation of line of movement and distance calculation. Turing and movement of vehicle in a farm land are shown in figure 3. Deviation of the vehicle depends on the speed and steering angle of the vehicle.
Deviation or error increases with increase of speed and steering angle. Steering response time at various forward speeds and angles are shown in graph (figure 4). At greater steering angle and speed, the response time of the wheel decrease therefore slipping tendency increases.
VI. APPLICATION OF AUTOMATIC VEHICLE IN AGRICULTURE FIELD

A. Vehicle used as a Tractor-
Automatic tractor saves time, increases farm efficiency and lowers the overall cost. By calculating its current position and the path that it needs to follow, a robotic tractor can drive a precise path, perfectly matching rows to one another in the thickest fog or the dark of night.

B. Variable-rate fertilization-
Once soil samples are transformed in nutrient maps and a fertilization program is on the way, a farmer may opt to use specialized machinery to deliver variable quantities of nutrients based on field requirements and GPS location. The ability to vary the quantity of fertilizer being delivered to different places is the heart of a precision farming plan. The logic is simple to adjust fertilizer delivery based on field requirements instead of delivering a blanket rate for the entire field.

C. Spraying-
In its simplest form, a GPS can be used to relay sprayer speed to a controller so it can adjust system flow to match the required volume. Variable-rate spray maps can be developed, and GPS receivers can be used to relay machine location and speed.

D. Harvesting-
A yield monitor and a GPS receiver can aid a producer in mapping yield variation throughout the field. Yield maps are used in a variety of ways, such as provide information for future long-term fertilization programs, variety trials and contract negotiation.

E. Planting-
The same concept of variable-rate fertilizing can be applied to planting. Machinery can actually vary the number of seeds per linear foot according to a map and GPS coordinates. Planting in straight lines is shown in figure 5.

Figure 5. Planting in straight line

VII. CONCLUSION
Automatic farming vehicle is more efficient than the manually operated farming vehicle. Performance of this automatic farming vehicle is far better than conventional farming vehicle. Driver cannot drive a conventional farming vehicle with constant speed. Therefore distribution of seeds cannot possible by manually operated farming vehicle. This automatic farming vehicle helps to precise the farming. Using accelerometer with GPS receiver, accuracy of position is increases. Therefore we use this accuracy for estimating the accurate positions for seeding, fertilizer utilization, pesticides utilization and problem areas in crop such as weeds or disease.
VIII. REFERENCES


Stanford University, Stanford, California.