Mechatronic Systems for Precision Agriculture

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ABSTRACT
Indian agriculture, even after the Green Revolution, is not as productive as it could potentially be. It calls for a second Green Revolution – one of precision agriculture, where cutting-edge technology is used to maximize production with minimum input costs and resources. Precision farming, precision agriculture is a management system where crop production practices and inputs such as seed, fertilizers and pesticides are variably applied within a field. Input rates are based on the needs for optimum production at each within-field location. Since over application and under-application of agrochemicals are both minimized, this strategy has the potential for maximizing profitability and minimizing environmental impacts. In this paper we propose some of the precision agriculture mechatronic systems which if applied in the Indian agriculture will result in upliftment of rural masses.

Keywords
Precision agriculture , Mechatronics ,Control Systems.

1. INTRODUCTION
The green revolution changed the very technology that was being applied in the Indian agricultural system. It showed great results and made India agriculturally self sufficient. But these technologies have remained untouched since then and no major improvement has been made to step up productivity to meet the demands of the burgeoning population. The new trend for improvement in agricultural production is that of precision agriculture. Some of the major problems in Indian agriculture are raising input costs, availability of skilled labor, dwindling water resources, over usage of fertilizers and lack of proper crop monitoring. Overcoming some of these problems requires tedious manual work which due to unavailability of enough labor cannot be performed. Hence, one of the solutions could be involving automation technologies in agriculture. Agricultural automation could help farmers single headedly maintain their crops and optimize usage of resources. Here, we present the technologies of implementing some of the methods of precision agriculture such as precision irrigation, soil based application of fertilizers, de-weeding and crop monitoring.

2. PRECISION AGRICULTURE
Precision agriculture involves the adequate and optimum usage of resources based on various parameters governing crop yield. The Handbook of Precision Agriculture[1] defines Precision agriculture as a holistic and environmentally friendly strategy in which farmers can vary input use and cultivation methods – including application of seeds, fertilizers, pesticides and water, variety selection, planting, tillage, harvesting – to match varying soil and crop conditions across a field. It is a management philosophy or an approach to agriculture where critical factors that affect yield are identified, and intrinsic spatial variability is determined. It is essentially more precise farm management made possible by modern technology. The variations occurring in crop or soil properties within a field are noted, mapped and then management actions are taken as a consequence of continued assessment of the spatial variability within that field. In the following sections various mechatronics control schemes and technologies in precision agriculture are discussed.

2.1 Variable Rate Seeding
There is development of using on-the-go sensors to Variable rate application of seeding (Figure 1). There are soil organic matter (SOM) sensors that detect different levels of organic matter and adjust the plant population rate accordingly. Soil moisture meters that may be used for depth adjustment and for changing seeding rates are available. As shown in Figure 1 on-the-go sensor (texture, electrical conductivity (EC), or soil organic matter (SOM)) measures soil characteristics before planting and adjusting the seeding rate [2].

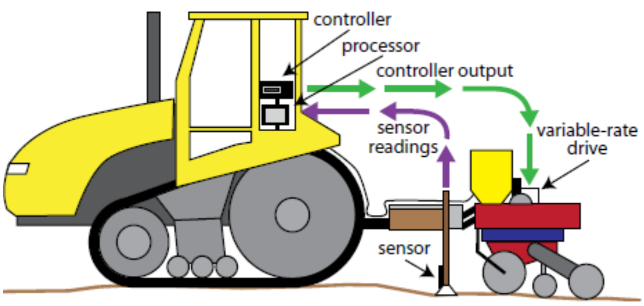

Figure 1. Variable Rate Application of Seeding

2.2 Site Specific Spraying of herbicides

Agricultural production suffers from severe losses due to insects, plant diseases, and weeds. Owing to an exponentially growing world population, crop protection has become one of the most important field operations for increasing productivity and crop yield. The most widely used practice in weed control is spraying herbicides uniformly over the agricultural fields at various times during the cultivation cycle of arable crops. To guarantee their effectiveness, over application of pesticides is commonly advised; however, excessive use of pesticides raises the danger of toxic residue levels on agricultural products. Because pesticides, and especially herbicides, are a major cost factor in the production of field crops and have been identified as a major contributor to ground water and surface water contamination, their use must be reduced dramatically. Fortunately, most weed populations develop in patches in the field, with large areas of the field remaining free of weeds or having a very low weed density in the early stage of infestation. As a consequence, herbicides would be used more efficiently if they were applied in the appropriate dose, where they are needed, and not to areas with insignificant weed densities. Thus, weeds have been suggested as the primary target for spatially selective pest control. The figure 2 shows one such method of selective pest control. Weed monitoring and spraying are carried out sequentially in the same operation (the real-time concept). A real-time weed detection system mounted on the field spraying machine detects "individual" weeds and transmits that information to a control system that controls the spraying equipment of the vehicle. This is called weed-activated spraying[3].

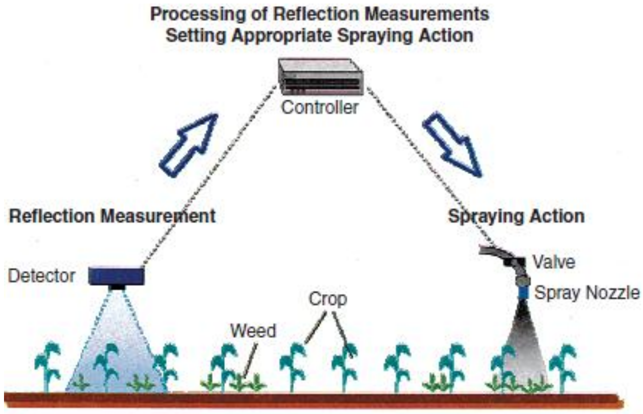

Figure 2. Site Specific Spraying of herbicides

2.3 Variable Rate Fertilizer Spreading

During the spreading of liquid manure, several factors may cause an application that is not in agreement with the needs of the plants and the capacity of the soil. Taking the actual demand as determined by soil analyses and the previous take-away by harvesting, there are some aspects that must be observed during application. At first, the manure may not be homogeneous if it was stored in a manure tank for some time. This effect can be eliminated by intensive mixing of the manure within the stationary tank before filling the tank trailer. The actual nitrogen content of the manure must then be determined to calculate how much (e.g., what volume) should be applied per hectare. According to the principles of precision farming, the amount should be calculated for small portions of the field, since the demand may vary greatly from area to area[3]. Therefore, the flow controller of the tank trailer must react to set-point changes quite rapidly. This also holds, particularly in hilly regions, for varying tractor speed caused by wheel slip. Another situation in which high-speed action of the flow controller is required is during startup and stopping of the tractor when reaching the boundaries of the field. The actual reference values, measurements, and parameters are transmitted to the spreader by the agricultural bus system. Various principles are known for the operation of slurry tank spreaders. Here, as shown in figure 3 flow control by branching is used: The (more or less constant) flow of the pump is split into one stream that is redirected into the tank and another stream that is fed into the spreading device. This principle has the advantages that it does not require a volumetrically operating pump and that the manure is continuously mixed in the tank trailer, since a certain part of the pump flow is refed into the tank.

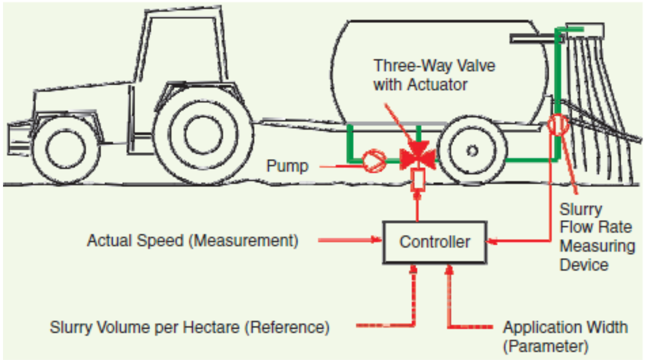

Figure 3. Variable Rate Fertilizer Spreading

3. INTELLIGENT SYSTEMS IN PRECISION AGRICULTURE

For the effective control of plant production, it is efficient to monitor the current physiological status of the plant and then use this information for control. Such an approach is known as the "speaking plant approach (SPA)," where the environmental factors are considered to be the input and the plant responses the output . Generally, however, it is very difficult to control the plant responses because the physiological processes are quite complex and uncertain. Intelligent control approaches are more suitable than traditional mathematical methods for dealing with complex systems such as cultivation systems .NNs have the capability to identify unknown complex systems with their own learning ability . GAs are one combinatorial optimization technique. Using a multipoint search procedure, they search for an optimal value of a complex objective function by simulating the biological evolutionary process based on crossover and mutation in genetics .The Figure 4 and Figure 5 shows the application of a new intelligent control system consisting of a decision system and a feedback control system to optimize plant growth in hydroponic tomato cultivation. The decision system, which consists of NNs and GAs, provides the optimal set points of the nutrient concentration to maintain a balance between vegetative and reproductive growth. The control input is the nutrient concentration of the solution, and the controlled output is the growth of a tomato plant.

In this method, plant responses affected by environmental factors are first identified using NNs, and then the optimal environmental set points are searched for through simulation of the identified NN model using GAs

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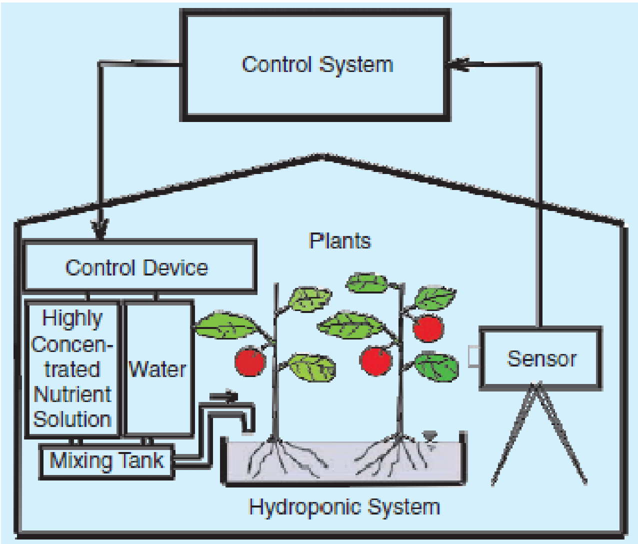

Figure 4. Control System for Hydroponic System

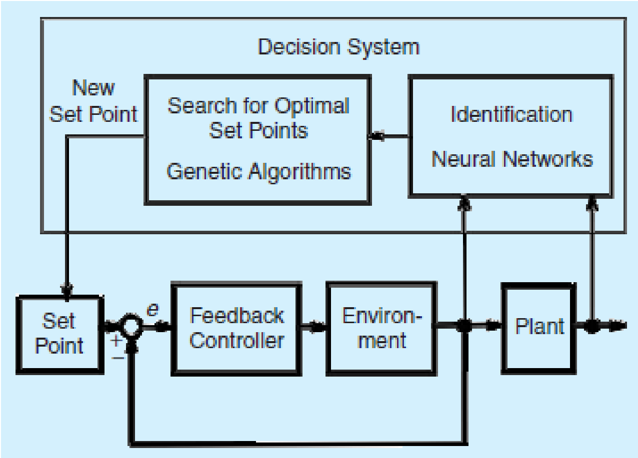

Figure 5. Feedback control and decision system

4. CONCLUSION

Precision agriculture techniques discussed in this paper, if applied in the Indian agricultural fields will result in –

- Increased yield of agricultural produce
- Improved production efficiencies
- Reduced agricultural impact on environment
- Appropriate and precise application of pesticides, herbicides and fertilizers.
- Prevention of excessive application of fertilizers and pesticides.
- Reduction in toxic residue in agriculture produce.

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6. REFERENCES

[1] Ancha Srinivasan. Handbook of Precision Agriculture, 2006.

[2] Robert Grisso. Precision Farming Tools : Variable Rate Applications, Verginia cooperative extension, Publication 442-505.

[3] Jose De Baerdemaeker ,Axel Munak ,Herman Ramon and Hermann Speckmann. Mechatronic Systems Communication and Control in Precision Agriculture, IEEE Control Systems Magazine,October-2001,pp- 48-70.

[4] Yasushi Hashimoto , Morimoto , and Toru Torii. Intelligent Systems for precision agriculture in Japan, IEEE Control Systems Magazine,October-2001,pp- 71-85.