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System Requirements for a Child Safety System

Every year children have fatal accidents on farms from tractors and attached implements. The frequency is increasing, since the machines are becoming bigger, more complex and have more blind spots. With fewer workers more land and livestock are being managed, which causes the work pressure to increase as well. The goal of this study is to define system requirements for an electronic driver assistance system.

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Collaboration with public institutions and businesses
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Keywords

Driver assistent system, radar technology, short wave field, children, tractor, agricultural machines and implements

For children, farms can seem a technological playground that is both inspiring and fascinating. On a regular basis, however, both adults and children forget that this setting can potentially also be life threatening. For example, every year in Bavaria up to one in five children die. Similar results can be found in Baden-Württemberg, Saxonia and Finland. In the United States or in Australia, where nearly a third of all children grow up in agricultural households, a registered yearly average of up to twelve deaths occur, as do thousands more injuries. For every child's death, there are ten children who are injuried to the degree of being permanently handicapped. Unsafe situations present a worldwide rate of a thousand to ten thousand times greater. Most of the fatalities are caused by accidents that occur around farm vehicles and related machinery. Around 50% to 90% of deadly accidents, have, until now, occurred when the vehicles are moving backwards or in otherwise careless manoeuvres.

Due to the complexity of agricultural machinery and the fine line separating work and home there are gaps in the safety system which require more than basic preventative measures. The technical system demands for a driver assistant system which identifies or detects children would have to be defined in a way so that any resulting safety gap resulting from a lack of precautionary measures by children and adults or design and environmental factors could be eliminated.

Analysis of accident causes

There are a variety of factors effecting the likelihood of children's accidents. These include threats in the environment, the child's physical and psychological characteristics at developmental stages, and the manner in which the adults use their own authority.

System failures resulting in accidents can be triggered by adults and children in agricultural machinery's surroundings. Because fewer family members work on farms it becomes more difficult to constantly pay attention to areas outside of immediate work perimeters and pay close attention to children's activities at all times.

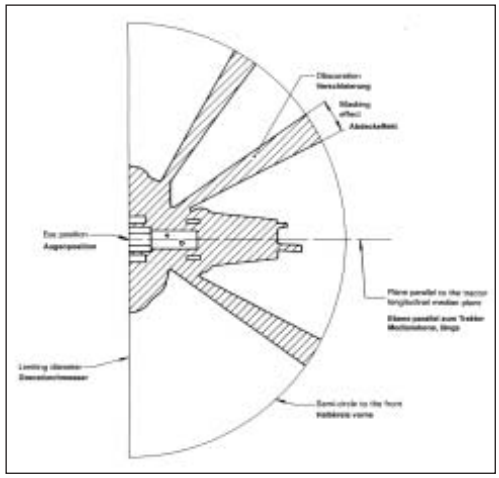

Fig. 1: Semi-circle of vision to the front

Children's behaviour is spontaneous, curious, and often imitates adults' activities. This may be the reason why they also seek play areas in close proximity to agricultural machinery and equipment.

Fatal accidents, where children are run over, have been the result of the following typical circumstances:

- children run towards the moving vehicle and are run over by either the vehicle itself or the attached trailer
- children hide in (for example in the tire rim), underneath or behind the vehicle or close to it and are hit either from the running vehicle or the attached machine.

The design of tractors, their stock on farms and the design of farm stead, field, construction and other areas, can limit the driver's field of vision independendly of behaviour. Vehicle parts, like the hood and the side fenders, exhaust and roof are all key components in restricting drivers' vision. The angle of vision is limited by these components' placement (*Fig. 1*). The worst-case-scenario can be figured out following the geometrical principal called intercept theorems. The scenario was tested by using a Steyr 8090 Turbo with a trailer in unsafe situations. The invisible area (blind spot) extends from next to the rear tires across a distance of 2.8 m and 1.6 m across the front of the hood. The first

result indicates, for example, that a 0.75 mr tall child has to be standing at least 1.6 m or crawling 2.3 m sideways from the rear tire to be seen, if the driver is looking sideways. With a trailer, the field of invisibility reaches 100% in the back, increasing from the front towards the back, and on either side of the machinery. The visibility problem becomes increasingly critical as the sizes of farm vehicles increase respectively. The length, width, and height of standard-sized tractors with the same amount of power have barely changed in the last decade. An important fact however is that older tractors have been replaced by stronger tractors.

Both danger and market potential for risk-decreasing measures are defined by the machinery stock. Worldwide there are 26.3 million tractors and 4.2 million self-propelling units in use.

In the worst case scenario, including inconvenient roads and impulse reactions, a tractor with a trailer moving at a speed of 10 kph requires three meters to stop. Moving at a pace for 12 kph four meters are needed to come to a complete stop. Assuming that a child is not seen within distance of the moving vehicle and that the breaking speed is less than the above-mentioned speed, the distance needed to come to a stop almost doubles. At reverse driving speeds of up to 4 kph a maximum of 1.5 m is needed to come to a complete stop. On the other hand, if the child is running or moving towards the vehicle, the necessary distance for coming to a complete stop increases respectively with the speed of the approaching child. When driving forwards, the driver needs to recognize the child at a distance of at least eight meters to prevent a collision. When driving backwards, only a few meters allow for enough time to stop. To be able to offer comprehensive protection for children, they need to be able to be detected even through obstacles.

Fig. 2: Demonstrators: sensor with alarm unit (left) and transponder (right)

System choice and build

Safe and instant recognition of children is only possible with large technical and financial costs, including optical, infrared and electronic technologies. An alternative source for reliable vehicle recognition could be indirectly, via a signal, a so-called transponder that people could carry with them and use. A possible technological base would combine of a slumbering microwave transponder used for recognition within larger distances with a short wave transponder for recognition within the immediate environment that works through coupling in a high frequency electronic rate.

The principle of electronic communication in immediate surroundings is based upon the fact that every electronic conductor (metal) produces an electromagnetic field across the earth. Even the human body produces a weak electromagnetic field which can be used to achieve reciprocal influence (coupling). By carrying and carefully using a slumbered microwave transponders, coupling can be achieved. There are no blind spot areas, since the transmitter's aura takes all parts of the tractor and any attached machinery into account. During forward movement the transponder recognizes objects within a distance of up to a mere 2.5 m. This means another type of technology - which is used in radar technology - needs to be implemented.

Radar technology makes it possible to record movement occurs over ten meters away. At the same time the transmitter receiver picks up signals from a specific transponder.

From an adult's perspective, children should not be allowed to wear active signal senders. The alternative solution would be a slumbered microwave transponder which could be activated in short term and could reflect a locally calculated and unique radar signal within a frequency range. The resulting signal movement would be similar to a mirrored reflection.

The communication element necessary to detect people are transponders, sensors and alarm units. The assembly of the driver assistance system is presented in *Figure 2*.

The transponder, the so-called identity disc, is carried by children and serves as a presence control. This interacts with the machine sensors and is then uncovered and selected in the UHF-zone and the HF-zone. The unity module is made of a HF-receiver to pick up signals in the electrical field and the double radar that picks up the signals via a back scattering method on a rear engine basis. The transfer of the alarm signal follows a HF-sender and decoding over a micro-controller.

The alarm unit receives the warning signal over a HF-receiver. It also guides the decoding over a micro-controller resulting in the distribution of the alarm signal to the optical and acoustic signal sender, or optionally, to an electronic interface on the board host. As the vehicle is started up, the ignition will activate the driver assistance system while the control function is secured so that children who are not visible, can be recognized.

Result and prospects

The development of a safety system that can guarantee the recognition of people in any given place or situation within the surrounding of a farm vehicle will enable greater child safety measures. The work group ZENO at the University for Natural Resources and Applied Life Sciences is supporting this development. Their goal is to finish developing the above described prototypes. They intend to test the systems under representative conditions so that the described dangers can be realistically controlled and ultimately contribute to child's safety on farms.

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