MANOMOTION

2021

WHITE PAPER

Raising hand safety with AI-powered hand tracking

ABSTRACT

This white paper outlines how artificial intelligence and machine learning technologies, combined with standard sensors, can drastically reduce industry-related hand injuries. By detecting hands and anticipating their movement, an application leveraging hand tracking can shut down machinery and generate visual or audio alarms warning people when their hands are in danger — while remaining compliant and introducing new safety regulations.

IS THIS WHITE PAPER FOR YOU?

If you are involved in an industry that includes manual steps where hands are exposed to cutting, pinching, grabbing, heat, cold, pressure, or chemical or biological substances and you are you in some way responsible for preventing industry-related hand injuries, then this white paper is a must read.

And even if you work in any of these areas:

- Safety regulations or overseeing regulations on driving safety.
- Product or process development and have an interest in equipment safety.
- Production and sales of machines or solutions that expose hands to risk.
- Providing professional services in the field of safety and safety solutions.
- Occupational health and safety regulation and compensation

Do you oversee a company that needs to prevent accidents due to moral or legal obligations? Are you motivated by the commercial opportunity that safety can deliver — allowing you to differentiate your product offering, or even create new products?

Whatever your position, industry, when you've reached the end of this paper, we hope you will have gained an understanding of:

- How AI/machine learning and sensors can detect hands, using hand tracking.
- Implications of automatic hand detection and possible solutions.
- Some of the technical challenges.
- How ManoMotion can help you move from the process of product innovation to full production or commercialization, helping your business in the pursuit of zero hand injuries.

Primarily, we want you to be able to answer this question:

> *Is hand tracking technology an opportunity for your business to reduce hand injuries?*

THE PROBLEM

Despite mature safety regulations and a culture that tends toward compliance, every three days somebody undergoes a finger amputation in Sweden — a result of a work or industry-related incident. Hand injuries not only cause suffering, loss of earnings, and potential disabilities for individuals, the overall cost implications are colossal. The average cost per injury ranges upwards of USD 600 to about USD 26,000 — not including complex injuries (where cost can be limitless) *and* excluding loss of production.

To add insult to injury, research suggests that most accidents are avoidable, it's simply a question of individuals and industries complying with existing regulations. But humans make mistakes. And that's where automation comes in. By automating safety compliance, we can take the human out of harm's way.

THE EVOLUTION OF HAND TRACKING AND ITS USES

Hand tracking is a sensor technology that detects a person's hand and how it moves. It is an enabling technology that provides applications with hand-gesture data that can be leveraged to control a device or interact with an object — without having to touch it. In addition to manipulation of real-world objects, hand tracking provides a means to remotely control virtual objects.

At the outset, hand tracking relied on sensor-equipped gloves to generate the necessary data. Today's gloveless hand tracking uses camera sensors that take images of a person's hands, leveraging computer vision for detection and interpretation of movement to generate an accurate set of data points in real time. Initially, dedicated camera sensors were required, but today, state-of-the-art AI and ML technologies make hand tracking viable using standard components.

Some examples of hand tracking in technology

Over the past few years, a wide range of applications that leverage hand tracking have reached maturity, including:

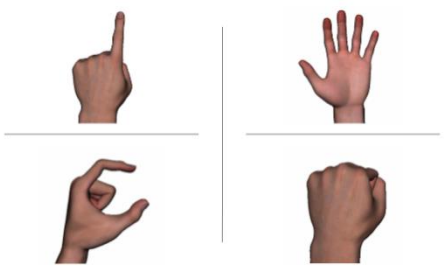
- Selecting buttons on a keypad by pointing.
- Switching TV channel by waving your hand to the left or right.
- Air swiping to open and close car windows in a car or change stereo volume.
- Navigating information displays/maps in shopping malls with gestures.
- Controlling mobile phones or computers with gestures.

The evolution of camera and sensor-based tracking are also evident in fields like automated driving and remote robotic control systems.

The shift to touchless

The coronavirus pandemic has pushed many touchscreen terminal vendors to reconsider their designs, pushing them to make the shift towards touchless, gesture-controlled solutions.

Today's approach to touchless, which relies on vendor-provided dedicated hardware solutions, is likely to evolve. The solution framework is rapidly moving toward native device integration, and in some scenarios, like mobile, it will be possible to adopt a software-only approach that leverages existing device sensors or standard cameras.



The IoT and sensors-everywhere trend imply that you can use hand tracking to communicate with and control any machine or device — and in some cases reduce cost by removing existing dedicated input hardware (such as keyboards).

Grab, pinch, and point are the future of machine interactions

Avoiding injury

Using technology to address safety in situations that include cutting, heat or cold, and biological and chemical hazards is not that common today. Instead, industries have opted for physical shields or rails in combination with carefully defined process steps, training, and protective gear to safeguard employees. Unfortunately, this kind of solution often has a negative impact on ease-of-use and productivity.

In situations where heavy lifting is required, or tasks that require repetitive hand/arm extension movements, robotics can be a way to eliminate hands from danger zones, but such solutions can also make tasks more awkward or introduce new type of risks.

HAND TRACKING AS A SAFETY APPLICATION

Introducing camera sensors and hand tracking technology as a means of raising safety in an industrial environment has three clear advantages:

1. Automates safety functions instantaneously.
2. Nonintrusive solution because it does not add new physical parts to the work environment.
3. Cost efficient because equipment does not need to be redesigned, ensuring that existing machine/equipment floor plans can remain in place.

#1 The sensors

The first step in the process is to introduce a standard sensor — such as an RGB camera, Lidar, IR, or VGA 640x480 — with proper line-of-sight of the hazard area. This sensor can be mounted on equipment, on a wall, or on another device or machine in the area. The sensor constantly monitors the dedicated area.

#2 The AI/ML middleware

The sensor streams signals to a middleware application on a processing unit, which could be the CPU of existing equipment or a dedicated one. There are of course technical requirements for this kind of CPU to ensure that it

powers the hand tracking technology in an appropriate way — something equivalent to Intel NUC11 (Intel Core i7 11th gen. 1185G7 / 3 GHz).

Using AI and machine-learning techniques, the middleware application is optimized for the specific environment, addressing factors such as distance, lightning, and other conditions such as the use of protective gloves. During the learning process the application masters tasks such as how to detect a hand in a specific area and movements that pose injury, as well as more advanced jobs like controlling the machine with gestures.

#3 The use-case application

Depending on the needs of the use case and risk scenario, the middleware application can send different types of signals to the equipment to execute a command. Shut down and stop commands are the most common, but other instructions — such as turn on warning lights, sound an alarm, flow cooling liquid, or apply rotational brake — are feasible. Almost any actuator with a coil, motor or directional flow control can be integrated with the control loop.

> ***The time between hand detection and command execution is measured in milliseconds***

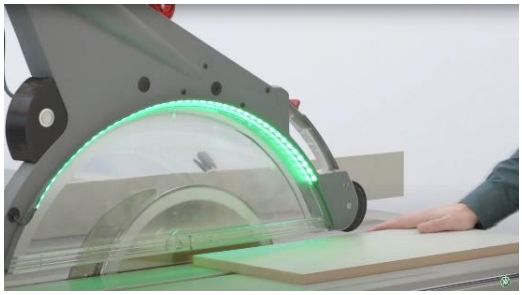
AN INDUSTRY COLLABORATION — MANOMOTION AND ALTENDORF

Our collaboration with Germany's Altendorf — the inventor of the sliding table saw — is a proof-of-concept example that illustrates how hand tracking has not only been successfully applied in a safety application but also received concept level certification by the German Occupational Safety Institute (IFA — Institute für Arbeitsschutz). The resulting application is the world's first safety-classified solution for industry-grade saws.

Altendorf challenged themselves to raise safety in the workplace by focusing on specific, well understood problem areas, without reducing machine performance or productivity.

The use of capacitive technology that detects liquids — such as blood — has been tried in table-saw industry. Once moisture is detected, the saw blade stops and, in some cases, the blade is destroyed. While this kind of solution reduces the impact of injury, it doesn't eliminate the problem. And because moist wood sometimes causes machines to stop, the solution is less than ideal.

To address this situation, prevent injury, and reduce the number of false alarms, The Altendorf Group developed their revolutionary Hand Guard System.



Altendorf is an example of insightful and ambitious leadership looking to solve hands-on problems in a traditional industry through the application of cutting-edge technology. Altendorf developed a new safety feature that uses hand tracking to detect when an operator's hands are getting too close to the saw blade, automatically shutting the machine down and rapidly moving the saw blade below the board line to prevent an accident.

The anticipating injury risk scenario based on hand positioning shuts the machine down before a person's hands are within the predefined hazard zone. The solution not only provides Altendorf with a unique selling point — to position and differentiate their product — it speaks to the industry they serve, helping to lower the number of severe injuries. For more information, check out the Hand Guard System (YouTube).

THE TECHNICAL CHALLENGES

Challenges

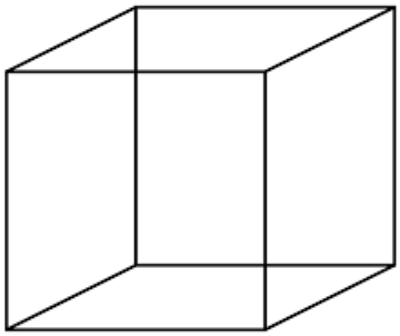
Before adopting AI/ML-based hand tracking to raise safety in your industry or workplace, there are some limitations for consideration.

- Occlusion — in some cases, the hand may not be the line-of-sight of the sensor some of the time. This limitation can significantly deteriorate the quality of hand detection and possibly limit hand tracking from a safety protection perspective.
- Distance — hand tracking has an optimal efficiency working range of 20 cm – 120 cm (between the sensor and the hand). Longer distances are feasible, depending on the environmental conditions.
- Field of view — detecting hands positioned directly in front of a camera sensor is accurate, however signal accuracy tends to deteriorate with wider view angles. This kind of issue can be addressed by adding extra sensors or by choosing a sensor with broader field of view.
- Environment — the overall environment will have implications on the capability to detect the hand with appropriate precision. Examples of environmental factors are background complexity, extraordinarily strong light, no light, vapor, and dust.
- Privacy — introducing sensors in workplaces should also include an analysis from a privacy perspective, including compliance for how data is stored and used.

These limitations are interconnected and affect performance, hence a simple trial set up is usually the best way to determine if hand tracking is a viable option to raise safety in a given environment.

Testing the viability of hand tracking as a safety technology

The concept used by ManoMotion is to first define a virtual 3D detection box that covers the danger zone. We then position the sensor at appropriate location and conduct detection tests, measuring success rates as limitations are introduced. Optimal performance can be achieved by moving the sensors to different locations or by adjusting factors such as lightning or background complexity. ManoMotion has developed an external camera system to facilitate this kind of exploration, which can help you to determine the viability of a hand-tracking based safety application.



The 3D detection box test

REGULATION AND SAFETY CERTIFICATION

The need for certification and compliance varies with industry, operating regions, and local regulations. Such conditions are out of scope for this white paper, but an area that we explore in collaboration with our customers.

> **ManoMotion worked with Altendorf on their Safe Hands table saw solution (Hand Guard™) until it had received concept level certification by Germany's BG/IFA.**

WHAT NOW?

Our ambition with this paper is to trigger ideas of how cutting-edge AI and machine learning coupled with standard sensors could improve safety and efficiency in your workplace.

Ask yourself the following three questions:

- Are there hand injuries in your industry?
- Having read this far, do you feel that preventive hand detection could help prevent these injuries?
- Do you feel that your scenario would pass the detection box test?

If you have answered yes to these three questions, you should consider contacting ManoMotion for a basic use case validation workshop.

The first thing we like to do is set up a call, where you tell us about your industry and your specific scenario. If we feel we can help you to solve your problem, we'll recommend a one-day exploratory workshop, which we

scope in collaboration with you. Or we can send you our rapid exploration kit, enabling you to connect a webcam to your application and start experimenting with hand tracking.

If at that point you decide to continue the project, we will send you a project proposal to help get you up and running with our software development kit. And if you want, we'll be there throughout your journey to commercialization, as much or as little as you need.

Qualification

- Conference call
- Joint qualification of the technical solution

Workshop

- Hands-on exploration
- Solution hypothesis

Prototype

- Working implementation
- Foundation for full project decision

ManoMotion is on a journey to save hands — let's explore this opportunity together!

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