INTELLIGENT ASSIST DEVICES

H. Kazerooni
University of California at Berkeley
Berkeley, CA 94720
kazerooni@me.berkeley.edu

Abstract

The Intelligent Assist Device [8, 9, 10] is a computer-controlled manual material handling system, which is designed to be used by a worker for repetitive pick and place tasks in various industrial settings, such as distribution centers, warehouses and auto assembly plants. In these assist devices, the operator force on the device is sensed and amplified electronically by use of a computer to drive the device actuator. In other words, the intelligent assist device extends the worker's physical power by adding mechanical power to the maneuvering task. The correct amount of power to add is calculated instantaneously in the device computer. The result is that the intelligent assist device lifts a pre-programmed larger percentage of the total force of the load (gravity plus acceleration) while the operator lifts the remaining much smaller percentage. This smaller percentage is sensed physically by the operator, so the operator has a feel for the load weight and inertia. With the assistance of the intelligent assist device, a worker can manipulate any object in the same natural way that he/she would manipulate a lightweight object without any assistance. There are NO pushbuttons, keyboards, switches, or valves to control the motion of the intelligent assist device; the device computer controls the motion of the device and its load. It has been shown that intelligent assist devices greatly reduce the risk of back injuries when used by workers performing repetitive maneuvers (e.g. depalletizing). This reduction in injury, in turn, will greatly reduce the national cost of treating back injuries.

The author has designed the Intelligent Assist Device (IAD) based on a solid scientific foundation with one goal in mind: minimizing the risk of injuries associated with repeated maneuvers and maximizing the throughput while being robust and user-friendly during repeated maneuvers. The author has evaluated the use of IAD extensively for three applications: warehousing and distribution centers (e.g. Target Stores), auto assembly plants (GM), and delivery services (US Postal Services). The evaluation has been both quantitative and subjective. This article first describes the Intelligent Assist Device characteristics and then gives an overview of its broad applications in various industries.

1 Description

Fig. 1 illustrates an intelligent assist device (IAD). At the top of the device, a computer controlled electric actuator is attached directly to a ceiling, wall, or an overhead crane and precisely moves a strong wire rope with a controllable speed. Attached to the wire rope is a sensory end-effector where the operator hand, the IAD, and the load come in contact. The end-effector includes a load interface subsystem and an operator interface subsystem. The load interface subsystem is designed to interface with a variety of loads and holding devices. In addition to hook shown in Fig. 1, suction cups and grippers are examples of other connections to the end-effector. In general, to grab complex objects special tooling systems should be made and connected to the load interface subsystem.

The operator interface subsystem includes an ergonomic handle, which contains a high performance sensor for measuring the magnitude of the vertical force exerted on the handle by the operator. A signal representing the operator force is transmitted to a computer controller, which controls the actuator of the IAD. Using the measurement of the operator force and other measurements, the controller assigns the necessary speed to either raise or lower the wire rope to create enough mechanical strength to assist the operator in the lifting task as required. If the operator pushes upwardly on the handle, the assist device lifts the load; and if the operator pushes downwardly on the handle, the assist device lowers the load. The load moves appropriately so that only a small pre-programmed proportion of the load force (weight plus acceleration) is supported by the operator, and the remaining force is provided by the actuator of the IAD. All of this happens so quickly that the operator's lifting efforts and the device's lifting efforts are, for all purposes, synchronized perfectly and the load feels substantially lighter to the operator. With this load-sharing concept, the operator has the sense that he or she is lifting the load, but with far less force than would ordinarily be required. For example, for a 50-lb. load force (gravity plus acceleration), the IAD supports 48 lb., while the operator supports and feels only 2 lb.

Fig. 1 shows the end-effector, which was engineered after many years of ergonomic research; it is compact, light, comfortable, ergonomically correct, safe and most importantly, reliable when holding a load. The end-effector reliably measures the operator forces at all times even in the presence of loading and unloading shock forces. This robust end-effector also includes a dead-man switch, which is installed on the handle and sends a signal to the controller via a signal cable. If the dead-man switch on the end-effector is not depressed, (i.e., if the operator is not holding onto the handle of the end-effector), the device will be suspended without any motion even if one removes or adds loads to the end-effector.

The IAD is engineered with variety of embedded safety features. One of the most important safety characteristics of the IAD is that the wire rope does not become slack if the end-effector is physically constrained from moving downwardly and the end-effector is pushed downwardly by the operator. The slack in the wire rope can have far more serious consequences than slowing down the workers at their jobs; the slack line may