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Fuzzy logic control for a soft exoskeleton glove using a motor-tendon actuator

[Control de lógica difusa para un guante de exoesqueleto suave que utiliza un actuador motor-tendón]

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Ismail, R. , Ariyanto, M. , Pambudi, K.A.
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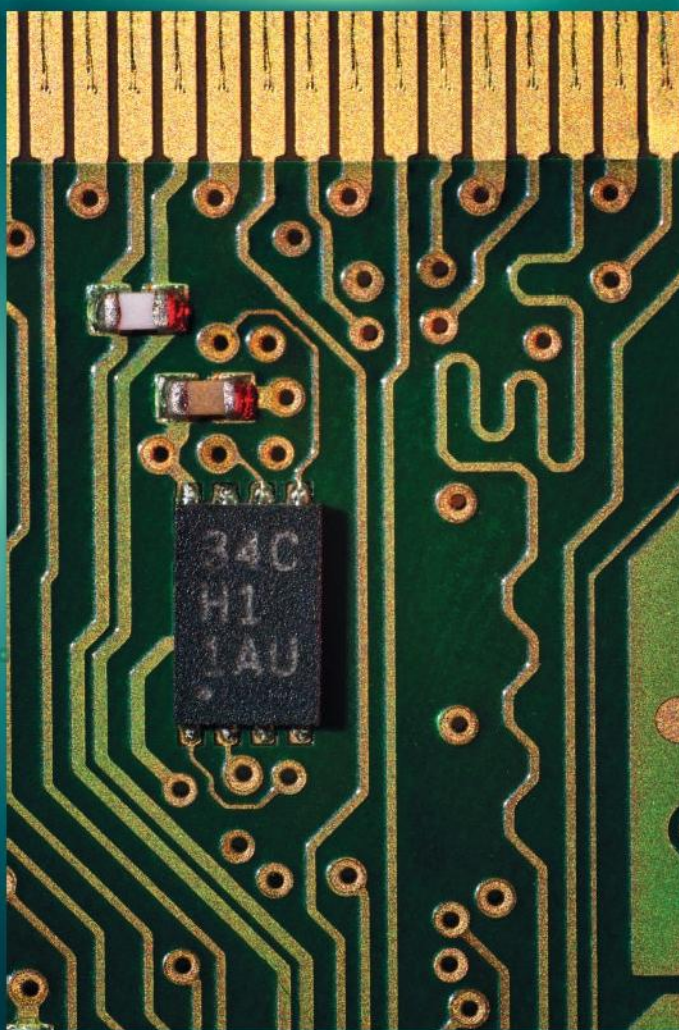
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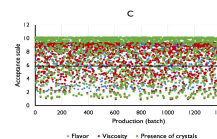
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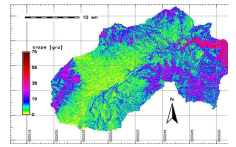
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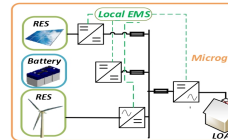
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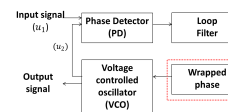
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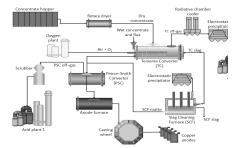
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Fuzzy Logic Control for a Soft Exoskeleton Glove Using a Motor-Tendon Actuator

Control de lógica difusa para un guante de exoesqueleto suave que utiliza un actuador motor-tendón

Joga Dharma Setiawan¹, Mochammad Ariyanto², Sri Nugroho³, Rifky Ismail⁴, Tedi Purbayanto⁵, and Haeryip Sihombing⁶

ABSTRACT

A hand is one of the essential limbs on the human body that is used for daily activities. The aim of this research is to develop a soft exoskeleton hand to assist people with hand deterioration. The developed exo-glove is made of low-cost RTV (room-temperature vulcanizing) silicone rubber with a motor-tendon actuation system that produces the flexion and extension motion. Here, the actuator converts rotation motion into linear motion from DC motor, while a potentiometer sensor is utilized to measure the rotation angle on the actuator system, in which fuzzy logic control (FLC) is employed for controlling the motion of the proposed motor-tendon actuator. To validate the function and mechanism of the developed soft exoskeleton glove, testing was conducted towards the FLC performance on the healthy human hand for various object grasping tests. Based on the test results, this study shows that the soft glove can be implemented on the human hand as an assistive device.

Keywords: fuzzy logic control, soft exoskeleton glove, assistive device, motor-tendon actuator

RESUMEN

La mano es una de las extremidades más importantes del cuerpo humano que se utiliza para actividades de la vida diaria. El objetivo de esta investigación es desarrollar una mano exoesqueleto suave para ayudar a las personas con la mano deteriorada. El exo-guante desarrollado está hecho de caucho de silicona RTV (vulcanización a temperatura ambiente) de bajo costo con un sistema de accionamiento motor-tendón que produce el movimiento de flexión y extensión. Aquí, el actuador convierte el movimiento de rotación en movimiento lineal del motor de DC, mientras que se utiliza un sensor de potenciómetro para medir el ángulo de rotación en el sistema del actuador, en el que se utiliza el control lógico difuso (FLC) para controlar el movimiento del actuador motor-tendón propuesto. Para validar la función y el mecanismo del exo-guante blando desarrollado se realizaron pruebas para lograr el rendimiento de FLC en la mano humana sana en varias pruebas de agarre de objetos. Según los resultados de la prueba, este estudio muestra que el guante blando se puede implementar en la mano humana como un dispositivo de asistencia.

Palabras clave: control de lógica difusa, exoesqueleto blando, dispositivo de asistencia, actuador motor-tendón

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Introduction

The hand is one part of the human body that has a significant role in carrying out daily activities. People with hand disabilities require a wearable robot that can help them perform as they did before. Two types of wearable robots are widely used for people with hand disabilities: prostheses and exoskeletons. Prosthetic hands, especially myoelectric hands, are an option for people who have lost a hand. There are many commercially available devices of this kind in the market today, but their price is not low enough (Ku, Lee, Park, Lee, and Jeong, 2019). Marks and Michael (2001) even stated that the cost have quadrupled as microprocessor control has steadily increased. Birnbaum (2016) stated in his report that these devices are a luxury rather than a necessity. The World Health Organization (Hill and Krug, 2017) underlined that, without access to prostheses or orthoses, people who need them are often excluded, isolated and condemned to poverty. Based on this, many researchers have been



Simulation Strategy to Reduce Quality Uncertainty in the Sugar Cane Honey Process Design

Estrategia de simulación para reducir la incertidumbre de la calidad en el diseño del proceso de miel de caña de azúcar

Victor Cerda-Mejía¹, Amaury Pérez-Martínez², Estela Guardado-Yordi³, Galo Cerda-Mejía⁴, Karel Diéguez-Santana⁵, Isnel Benítez-Cortés⁶, and Erenio González-Suárez⁷

ABSTRACT

This work proposes to increase the acceptability of the sensory quality attributes of sugarcane honey by simulating and decreasing the uncertainty of operational parameters. To this effect, it relies on the development of a case study through a strategy that contemplates the analysis of the initial data and performs calculations through the use of mathematical models, the determination of the Sigma quality level, and the use of the GUM methodology (Guide to the expression of uncertainty in measurement). It was demonstrated that a range with a great variability in the initial operational parameters generated a Sigma level of less than three and a decrease in revenues of 30-52% due to low product sales for the studied productions. By decreasing pH uncertainty from 3,79 to 4,21, and Brix degrees from 75,13 to 76,88, an increase in the Sigma level of quality was observed, which exceeded six, in compliance with product quality specifications, as well as a reduction in economic losses due to defective products. The importance of quality in the product design and the process is evinced, given its influence on the acceptability of the product and the feasibility of the process.

Keywords: sigma quality level, simulation, uncertainty, sugarcane honey

RESUMEN

El trabajo propone incrementar la aceptabilidad de atributos de calidad sensorial del jarabe de caña de azúcar mediante la simulación y disminución de la incertidumbre de parámetros operacionales. Para ello, se apoya en el desarrollo de un estudio de caso a través de una estrategia que contempla el análisis de los datos iniciales y efectúa cálculos a través del empleo de modelos matemáticos, la determinación del nivel Sigma de calidad y de la metodología de la GUM (Guide to the Expression of Uncertainty in Measurement). Se demostró que un rango con gran variabilidad de los parámetros operacionales iniciales generaba un nivel Sigma menor que tres y una disminución de los ingresos del 30 al 52 %, debido a las bajas ventas de productos en las producciones estudiadas. Al disminuir la incertidumbre del pH de 3,79 a 4,21 y los grados Brix de 75,13 a 76,88, se garantizó un incremento del nivel Sigma de calidad superior a seis, en cumplimiento de las especificaciones de calidad del producto, y una reducción en las pérdidas económicas por productos defectuosos. Se evidencia la importancia de la calidad en el diseño del producto y del proceso, dada su influencia en la aceptabilidad del producto y la factibilidad del proceso.

Palabras clave: nivel sigma de calidad, simulación, incertidumbre, miel de caña de azúcar

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Introduction

Within the agroindustry, there are crucial goals such as quality, which must respond to the growing demands of the consumer. The development of new products and agroindustrial processes results from the interaction of men, materials, and equipment, which should establish an organized system that enables the maximization of benefits (Prieto, Mouwen, López Puente, and Cerdeño Sánchez, 2008). In this sense, process design or redesign in this type of industry acquires a special importance, since it is possible to

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Analysis of the Efficiency of Traffic Lights Turning Red in Case of Exceeding Speed Limit

Análisis de la eficacia de los semáforos que se ponen rojo en caso de exceder el límite de velocidad

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ABSTRACT

Due to the presence of various traffic calming measures (TCM) and traffic lights in urban areas, the speed of vehicles is maintained low. Nevertheless, a problem arises in the frontier between urban and non-urban areas because drivers must adapt their speed and behavior to new conditions. This risk becomes even greater in rural roads that penetrate small villages without a bypass and with a short urban segment, since drivers do not normally speed down in these segments. Various measures can be installed, but traffic lights that turn red if the speed limit is exceeded is not usually considered as a TCM in the literature. Therefore, this paper aims to analyze the efficiency of traffic lights turning red in case of exceeding speed limit. The village of Ábalos in Spain was selected for this research, with an urban area of 630 m and this type of traffic lights in both directions. Results showed that drivers do not respect the speed limit - and hence, the red light - when they are placed separately. However, if they are placed next to a crosswalk, their effect is increased. Consequently, it is recommended to place these traffic lights with a crosswalk to reinforce the efficiency of both TCMs.

Keywords: traffic calming measure, road safety, urban area, pedestrian, traffic lights, speed limit, crosswalk

RESUMEN

Debido a la presencia de varias medidas de calmando de tráfico (MCT) y semáforos en zonas urbanas, la velocidad de los vehículos se mantiene baja. No obstante, un problema aparece en la frontera entre áreas urbanas y no urbanas porque los conductores deben adaptar su velocidad y comportamiento a nuevas condiciones. Este riesgo se vuelve incluso mayor en las carreteras interurbanas que penetran en pequeñas poblaciones sin circunvalación y con un corto tramo urbano, pues normalmente los conductores no reducen su velocidad en estos tramos. Varias medidas pueden ser instaladas, pero los semáforos que se ponen rojos si se sobrepasa el límite de velocidad no suelen considerarse como MCT en la literatura. Por lo tanto, el objetivo de este artículo es analizar la eficacia de los semáforos que se ponen rojos en caso de exceder el límite de velocidad. La población de Abalos en España fue seleccionada para esta investigación, con un área urbana de 630 m y con este tipo de semáforos en ambas direcciones. Los resultados muestran que los conductores no respetan el límite de velocidad - y por tanto, el semáforo en rojo - cuando son colocados por separado. Sin embargo, si son colocados junto a un paso de peatones, se aumenta su efecto. En consecuencia, se recomienda disponer este tipo de semáforos junto con un paso de peatones para reforzar la eficacia de ambas MCT.

Palabras clave: medida de calmando de tráfico, seguridad vial, área urbana, peatón, semáforo, límite de velocidad, paso de peatones

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Introduction

Despite the important decrease registered in the total number of fatalities in road traffic in developed countries during the last years, road safety is still a major problem around the world, and it has become the leading cause of premature death (Studer *et al.*, 2018; Ptak, 2019; Llopis-Castelló and Findley, 2019; Shah and Ahmad, 2019). To give some figures, in the European Union (EU-28), the number of fatalities in collisions decreased from 57 006 to 25 767 between 2000 and 2016 (54,7%) (EUROSTAT, 2018). In the United States, a rate of 35 000 people dead in crashes per year is registered (FHWA, 2018).

In Spain, even a higher decrease was observed in the same period (2000-2016), 68,7% (from 5 776 to 1 810) (EUROSTAT, 2018). In 2018, 102 299 accidents with injured people were

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