PRODUCTION LOGISTICS IN THE INDUSTRY 4.0 ERA

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AGENDA

PRODUCTION LOGISTICS AND INDUSTRY 4.0

MACRO-LAYOUT & MATERIAL HANDLING SYSTEMS

MICRO-LAYOUT & HUMAN-CENTERED WORKSTATIONS

CONCLUSION & FUTURE RESEARCH
Requirements of production and logistics systems 4.0

- Interconnection of production modules
- Routing flexibility of material handling systems
- Integration of production and logistics systems
- Dynamic reconfiguration
- Scalable automation
- Human-centered workstation
- Human-robot collaboration
- Real time access to production and materials info
- Simulation based on real time data
- ...

MACRO LAYOUT LEVEL

SMART MATERIAL HANDLING SYSTEMS
FLEXIBLE MHS = FLEXIBLE PRODUCTION SYSTEMS

SMALL MOBILE ROBOTS FOR PRODUCTION SYSTEM

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1. Introduction

Some of the most influential management concepts in the field of assembly systems have been the Toyota Production System and the Flexible Manufacturing System. Assembly systems are experiencing dramatic changes in response to emerging new trends, such as customer demands for shorter product life cycles and lower production times. The ability to offer customized products at competitive prices is critical for maintaining market share.

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Dimensioning of a Rail Guided Vehicles system with real throughput estimation

Càlimeres Martinet, Pereira Alexandre, Spagnosa Fabio

Abstract: An automated piece-to-picker picking system is composed of an automated warehouse, where automatic storage and retrieval systems (AS/RS) store the Stock Keeping Units (SKUs) of the various products. The warehouse is connected to the picking areas by conveyor systems, which transport the SKUs from the warehouse to the picking areas. The picking areas are equipped with robotic arms, which pick the SKUs from the conveyor systems and place them in the corresponding picking areas. The performance of the picking area is crucial in determining the overall performance of the picking system. In this paper, the authors present a method for estimating the throughput of a rail-guided vehicle system, which is used to transport the SKUs from the warehouse to the picking areas. The method takes into account the layout of the warehouse and the picking areas, as well as the performance of the rail-guided vehicle system. The authors present simulation results for a real-world case study, which show that their method is accurate and reliable.

Keywords: warehouse picking, piece-to-picker, rail-guided vehicles, picking throughput

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FLEXIBLE MHS = FLEXIBLE PRODUCTION SYSTEMS

SMALL MOBILE ROBOTS FOR PRODUCTION SYSTEM
Ultra Wide Band Indoor Positioning System: analysis and testing of an IPS technology

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Abstract: Due to their current operating context, all logistics processes, from the simplest to the most complex ones, are facing always more interesting challenges in terms of management of a huge variety of products and, at the same time, strict lead times. In such a framework, it turns out that logistics inevitably has to move at varying or, at least, reducing all the possible inefficiencies that could emerge during the execution of the various activities that are needed to deliver a required product to a customer. These inefficiencies could be, among others, delays in the searching of the needed product code within a warehouse, errors in the retrieval or in the picking of an item, waste of time for carts or for operators’ travelling activity, lack of availability of warehouse facilities and devices due to failures and breakdowns. Of course, the overcome of the inefficiencies has to pass through the retrieval of the information that can be useful to increase the awareness of such existing lacks. For example, it would be important to have the data related to the movements of resources and objects handling. In this paper, an innovative indoor positioning system is presented. Based on a real-time indoor location technology using Ultra Wide Band, it can be used for having an effective overview of a logistic system. After an introduction of the possible technologies for indoor positioning and tracking, the configuration of the system is showed, together with a description of a simple test and of an industrial application. The reported examples highlight some preliminary insights about the system accuracy and its applicability.

Keywords: indoor positioning, Ultra Wide Band, system test
MICRO LAYOUT LEVEL

HUMAN CENTERED WORKSTATION
OPERATOR WELL-BEING = PERFORMING SYST.

WEARABLE DEVICES FOR ERGONOMICS EVALUATION

New methodological framework to improve productivity and ergonomics in assembly system design

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Innovative real-time system to integrate ergonomic evaluations into warehouse design and management

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WEARABLE DEVICES FOR ERGONOMIC EVALUATION

A device to monitor fatigue level in order-picking
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A model for rest allowance estimation to improve tasks assignment to operators
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(Received 13 May 2017; accepted 10 June 2018)

Ergonomics in assembly line balancing based on energy expenditure: a multi-objective model
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(Received 27 December 2014; accepted 13 July 2015)

In many assembly systems, ergonomics can have great impact on productivity and human safety. Traditional assembly systems optimization approaches consider only time and cost variables, while few studies include also ergonomics aspects. In this study, a new multi-objective model for solving assembly line balancing problem is developed and discussed in order to include also the ergonomics aspect. First, based on main features of assembly workstations, the energy-expenditure concept is used in order to estimate the ergonomics level, thanks to a new technique, called Predetermined Motion Energy System, which helps to quantify the energy expenditure value. Then, a multi-objective approach, based on four different objective functions, is introduced in order to define the frontier of optimal solutions. To complete the study, a simple numerical example for a real case is proposed to analyze the behavior of Pareto frontiers varying several parameters linked to the energy and time value.

Keywords: assembly line balancing; ergonomics; multi-criteria decision-making; optimisation
WEARABLE DEVICES FOR IMPROVING KNOWLEDGE AND ASSIST OPERATOR

Ergo-Log – IMMERSIVE REALITY

Abstract: The paper presents the VII-Ergo Log system, an inertial motion capture system integrated with immersive reality and combined with a laser toe monitoring. By using immersive reality, the operator will be able to move and interact within a virtual workplace environment. In order to perform a fast and efficient ergonomic assessment of human workplace solutions and to avoid all co-occurring activities related to workplace ergonomics, the software application allows to evaluate in advance the time-based and ergo-based indices which can help practitioners in understanding how to design the workplace and the devices to be used by operators. In addition, the use of the laser toe monitor permits to have real-time feedback regarding the fatigue the operator is perceiving. The use of such a system will help to make easier the early design phases of an industrial system, by also considering the impact of human diversity and avoiding non-ergonomic solutions especially when on spring workstations will be needed in the system.

Keywords: motion capture system, virtual reality,ergonomics, human-centred workplace, ageing workers

A comparative analysis of different paperless picking systems

Abstract: Purpose: Warehouse picking is often referred to as the most labour-intensive, expensive, time-consuming operation in retail warehouses. These factors are becoming even more acute due to recent trends in manufacturing and warehousing requiring the processing of returns, that are often both large and time-critical, in a structured way. For this reason, in recent years there has been a lot of interest and better picking systems. The purpose of this paper is to introduce a comparison of five paperless picking systems: i.e., hand-held, RF based, voice picking, traditional pick-by-lights, WMS based warehouse. The efficiency of each system is measured through the ratio of the completed picking tasks to the total time spent on picking activities.
CONCLUSION & FUTURE RESEARCHES

...to make production and logistics systems smarter, more flexible, more adaptable, more scalable, more interconnected, in the industry 4.0 era it is necessary to:

**FLEXIBLE MHS = FLEXIBLE PROD. SYST.**

- New MHS (small mobile robots)
- Interconnection of prod. & log. syst.
- New models to design them
- New models to manage them
- Impact of real-time info
- New models for buffer design
- Impact of automation
- ...

**HUMAN-CENTERED WORKSTATIONS**

- Wearable systems for HF analysis
- Integration of assistive technologies
- New models for workstation design
- New models for operator mng
- Materials Exposure and Mng
- Human-Robot Collaboration
- Ageing workforce
- ...

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THANKS FOR YOUR ATTENTION

ANY QUESTIONS FOR MY ANSWERS?

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FABIO SGARBOSSA
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A Decade of the Physical Internet: Informing Future Initiatives
A worldwide initiative

2007
SCs collaborations

2009
The name is found...

2011
Projects in Fr & USA

2013
Dissemination, industry and awards

2015
European dimension

2018
Academic recognition
1st IPIC

Start-ups
Chaîne
An opportunity and responsibility

How to build coordination and trust in a new system?

- Collaborative design of 5 roadmaps towards physical internet components and guidelines
- At European level only...

alice

Alliance for Logistics Innovation through Collaboration in Europe

http://www.etp-logistics.eu
Physical Internet works when it exists!

- If we have a reconfigured network, the right cost function, the goodwill of the players then it works…

How?

Do we have an evidence it could exists somewhere?

Interconnection platforms: typical solutions

How to interconnect?

- Fragmentation
  - “Silo effect”

- International treaty
  - “UN bureaucracy”

- Interconnection
  - “Decentralization & trust”

- Dominant position
  - “The winner takes all”

E. Ballot 2018
An example with ecommerce deliveries

When consignees are not part of the system: missed deliveries, multiple deliveries per day...

Eric.ballot@MR Pasha
What we have not been able to solve yet

- The reallocation problem: an example

Red carrier:
- 3 v.d
- 5 u.d

Blue carrier:
- 2 v.d
- 3 u.d

Total: 5 v.d and 8 u.d

2 transport requests for each carrier
Reallocation?

Red carrier:
- 3 v.d
- 5 u.d

Blue carrier:
- 2 v.d
- 3 u.d

Total: 5 v.d and 8 u.d

2 transport requests for each carrier

Red carrier:
- 2 v.d
- 3 u.d

Blue carrier:
- 1 v.d
- 2 u.d

Total: 3 v.d and 5 u.d

2 transport requests for each but reallocated
Our latest research tool
### The methodology

#### Current market vs. PI approach

<table>
<thead>
<tr>
<th>Optimal solution</th>
<th>Current market</th>
<th>PI approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reallocation</td>
<td>No reallocation</td>
<td>Reallocation is possible</td>
</tr>
<tr>
<td>Computer optimization</td>
<td>Computer optimization</td>
<td>Computer optimization</td>
</tr>
<tr>
<td>Proposed Reference Rate Structure</td>
<td>Proposed Reference Rate Structure</td>
<td>Proposed Reference Rate Structure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solution with players</th>
<th>Current market</th>
<th>PI approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reallocation</td>
<td>No reallocation</td>
<td>Reallocation is possible</td>
</tr>
<tr>
<td>Players playing the game</td>
<td>Players playing the game</td>
<td>Players playing the game</td>
</tr>
<tr>
<td>Players offer their own rates</td>
<td>Players offer their own rates</td>
<td>Players offer their own rates</td>
</tr>
</tbody>
</table>

- **Analysis of the performance of the PI approach**
- **Study the performance of the players comparing to the optimal solution**
- **Analysis of player behavior with new mechanisms**

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E. Ballot

2018
In action

Player interface - Truck Game

You are the player 2
You are in the round 1
Which road do you choose? (ex: 1-4-5)
Which request do you choose? (ex: 8-14-9)
Which margin? (percentage between 0 and 100)

Send the file

If you do not want to submit a price for this round, go to the next round and wait [click here]

Summary:
You chose the road 1-5-8
You chose the request 2-3
You chose the margin 13%

If you want to add a new offer in this round: [click here]
If you want to go to the next round [click here]
Data has been correctly added!
Warehousing 4.0

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Savannah, July 24, 2018
Agenda

→ Intralogistics 4.0 and warehousing
→ Smart bins, containers, storage rack
→ Robotized storage and picking systems
→ Conclusions
Intralogistics 4.0 and warehousing

FEM Statistics – Order Intake Intralogistics Systems

Source: https://www.fem-eur.com/
Würth Industrie Service was the first C-Parts supplier (January 2013) to introduce an optical ordering system that will revolutionize materials management for a long time to come.

The quantity, number and ordering information for the item can be obtained at bin level via the built-in camera; this is then transmitted to the ERP system automatically.

Smart Containers

→ self supported
→ graphic display
→ 256 bit μProcessor
→ energy storage
→ communication

The first real intelligent bin communicates with people and machines, takes decisions independently, supervises its environmental conditions and controls logistics processes. The charge carrier transforms itself into a »co-thinker«.

© inBin ist eine Marke der Fraunhofer-Gesellschaft
Source: https://www.iml.fraunhofer.de/
Smart Storage Racks and Pick-by-Vision

The classic "human-machine-interface" is changing.

Before: Operator enters a terminal / machine.

Afterwards: An operator is permanently connected to the "social networks" of an Industry 4.0 via an "Assistant Device". Operator communicates with other people as well as with cyber-physical systems.

Source: Michael ten Hompel, Logistik 4.0, Auswirkungen von Industrie 4.0 in Logistik und SCM.
Source: https://www.doag.org/formes/pubfiles/5817351/2014-Logistik-IND40-Michael_ten_Hompel-Keynote__Logistik_4_0_Auswirkungen_von_Industrie_4_0_in_Logistik___SCM-Presentation.pdf
Robotized storage and picking systems

→ AVS/RS

→ Movable racks with robots

→ AGV based picking

Source: SSI Schäfer

Source: Amazon Robotics

Source: Bastian Solutions, Kuka, Dematic
Autonomous vehicle storage/retrieval systems

→ Shuttle carrier horizontal movement, only
  - SSI Schaefer
  - Knapp
  - Vanderlande
  - Dematic
  - others...

→ Shuttle carrier horizontal and vertical movement
  - Swisslog (Autostore)

→ Shuttle carrier horizontal and diagonal movement
  - Rack Racer (Fraunhofer IML)
Autonomous vehicle storage/retrieval systems

Shuttle-Based Storage and Retrieval Systems (tier-captive shuttle carriers).

Shuttle-Based Storage and Retrieval Systems (non-tier-captive shuttle carriers)

Shuttle-Based Storage and Retrieval Systems (multi-tier-captive shuttle carriers)

Shuttle-Based Storage and Retrieval Systems (3D-level-captive shuttle carriers)
Shuttle-based systems

Source: SSI Schäfer (http://www.ssi-schaefer.de/lagertechnik/shuttle-systeme/cuby-einebenen-shuttle.html)
Movable racks with robots

→ Amazon Robotics
→ Grey Orange
→ Grenzebach
→ Scalog
→ and others...

Source: Kaveh Azadeh, René de Koster and Debiit Roy, Robotized Warehouse Systems: Developments and Research Opportunities
AGV based picking

→ Manual picking

→ Automatic picking

- Works with any forklift brand
- Easy to integrate with your Warehouse Management System
- Removes unproductive steps
- 60-100% higher picking productivity
- Safer and more accurate handling
- Forklifts use less energy and last longer

Source: Kollmorgen

Source: Bastian Solutions, Kuka, Dematic
Conclusions and further research

→ Robotic Mobile Fulfilment System
  - is an automated, parts-to-picker storage system where robots bring pods with products to a workstation.

→ Manual order picking with AGVs
  - routing, control, assignment

→ Interaction Man - Robot
  - operator 4.0

Source: Amazon Robotics
Source: SSI Schäfer
Thank you for your attention

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