PRODUCTION LOGISTICS IN THE INDUSTRY 4.0 ERA

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Fabrication Logististics and the 4.0

Changeable Production Systems Paradigm


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 SYSTEMS

1. Introduction

Some of the most influential management concepts assemble systems, from Henry Ford's assembly line to the more recent Toyota Production System and the Fordyce, assembly systems experienced dramatic changes and profound shifts in existing depressive and competitive environments. Modern markets demand fast, flexible, and efficient manufacturing systems. The ability to offer customized products at prices defined as mass customization will require a paradigm shift in design and management of assembly systems. Models have become essential as an owner before to customization that can be summarized in the following.

Dimensioning of a Rail Guided Vehicles system with real throughput estimation

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Abstract: An automated part-to-picker picking system usually consists of an automated warehouse, with Automatic Storage and Retrieval Systems (AS/RS) that returns the Stock Keeping Units (SKUs) of the various needed products from their stock locations, and of a picking area, with linear conveyor or robots that pick the needed items to then be exported to a picking station, or returns them to their stock locations. The automated warehouse and the picking area are connected by an automated transportation system, which can move the SKUs from the warehouse to the picking area, and the picking area to the warehouse, as required. The transportation system, usually a rail-guided vehicle, is the spine of the system, and its performance is critical for the system's effectiveness. In this paper, we present an analytical model for the dimensioning of a rail-guided vehicles system, based on real data from a 2018 study, and we use it to solve problems of real-life size in a certain picking throughput. In fact, it is shown that the picking throughput does not increase linearly with the number of vehicles employed, due to competition issues.

Keywords: warehouse picking, parts-to-picker, rail guided vehicles, picking throughput
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 reviving or, at least, reduce, 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 onerous 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 to 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 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

FLEXIBLE MHS = FLEXIBLE PRODUCTION SYSTEMS

INTELLIGENT MATERIAL HANDLING SYSTEMS
MICRO LAYOUT LEVEL

HUMAN CENTERED WORKSTATION
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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A device to monitor fatigue level in order-picking
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International Journal of Production Research, 2018
https://doi.org/10.1080/00207543.2018.1499316

A model for rest allowance estimation to improve tasks assignment to operators
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Ergonomics in assembly line balancing based on energy expenditure: a multi-objective model
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In many assembly systems, ergonomics can have a 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 Predicted Motion Energy System, which helps to estimate the energy expenditure values. Then, a multi-objective approach, based on four different objective functions, is introduced in order to define the efficient frontier of optimal solutions. To complete the study, a simple numerical example for a real case is presented to analyze the behaviour of Pareto frontiers varying several parameters linked to the energy and time value.

Key words: assembly line balancing; ergonomics; multi-criteria decision-making; optimisation

Heart rate trend

Trend of energy expenditure
WEARABLE DEVICES FOR IMPROVING KNOWLEDGE AND ASSIST OPERATOR WELL-BEING

Ergo-Log – IMMERSIVE REALITY

A comparative analysis of different paperless picking systems

Different paperless picking systems

Abstract

Purpose: Warehouse picking is often referred to as the most labour intensive, expensive and time consuming operation in material warehouses. These factors are becoming even more acute due to recent trends in manufacturing and distribution requiring the processing of orders that are highly varied and limited in a shorter time. For this reason, it is necessary to make picking systems and operators capable of picking items quickly and accurately.

Keywords: motion capture, system, virtual reality, ergonomics, human-centered, workspace, aging workers

Fabio Sgarbossa – fabio.sgarbossa@unipd.it 2018 IMHRC, Savannah, Georgia USA, July 23-26, 2018
...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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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: Start-ups, Chaire

Academic recognition: 1st IPC

E. Ballot 2018
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…

Do we have evidence it could exist somewhere?

Interconnection platforms: typical solutions

- How to interconnect?

- Fragmentation
  - “Silo effect”

- International treaty
  - “UN bureaucracy”

- Interconnection
  - “Decentralization & trust”

- Dominant position
  - “The winner takes all”
An example with ecommerce deliveries

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

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- - -

E. Ballot

2018
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
<table>
<thead>
<tr>
<th>Optimal solution</th>
<th>Current market</th>
<th>PI approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No reallocation</td>
<td>Reallocation is possible</td>
</tr>
<tr>
<td></td>
<td>Computer optimization</td>
<td>Computer optimization</td>
</tr>
<tr>
<td></td>
<td>Proposed Reference Rate Structure</td>
<td>Proposed Reference Rate Structure</td>
</tr>
<tr>
<td>Solution with players</td>
<td>No reallocation</td>
<td>Reallocation is possible</td>
</tr>
<tr>
<td></td>
<td>Players playing the game</td>
<td>Players playing the game</td>
</tr>
<tr>
<td></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
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/
Smart Bins

→ IBIN® - THE FIRST INTELLIGENT BIN

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«.
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 Debjit 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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