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BLUE GROWTH

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TECNOLOGÍAS Y PROCEDIMIENTOS PARA SU GENERACIÓN

INFORME DE VIGILANCIA TECNOLÓGICA

2020

Unión Europea

Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

RIS3 MUR

info REGIÓN DE MURCIA

Este informe ha sido elaborado por la Asociación Empresarial de Investigación Centro Tecnológico Naval y del Mar gracias al Convenio suscrito con el Instituto de Fomento de la Región de Murcia con el apoyo del fondo FEDER.

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1. Introducción

Este informe, elaborado por el equipo del Centro Tecnológico Naval y del Mar, tiene como finalidad ofrecer al tejido empresarial una mejora en el conocimiento del entorno, que permita detectar tendencias y desarrollar estrategias adecuadas basadas en niveles superiores de certidumbre a través de la captación y divulgación de información y conocimiento de importancia estratégica en los ámbitos social, tecnológico y económico, que incidan en la detección de nuevas oportunidades de desarrollo regional.

Los contenidos de este informe están estrechamente relacionados con el desarrollo del proyecto *Mining process & analysis for Digital Twin - Aplicación del Process Mining al modelado y análisis de proceso industriales con una alta componente manual para la creación de su Gemelo Digital*; financiado por el Instituto de Fomento de la Región de Murcia.

Para la realización de este informe se han aplicado técnicas de Vigilancia Tecnológica, una herramienta al servicio de las empresas y organizaciones que permite detectar oportunidades y amenazas aportándoles ventajas competitivas y fundamentos para la toma de decisiones estratégicas mediante la selección y análisis de información de diversos tipos (científica, tecnológica, comercial, de mercado, social…).

Para ello se parte de una introducción metodológica sobre las técnicas y fases de la Vigilancia Tecnológica que se han aplicado para el desarrollo del informe. A continuación se introduce el Crecimiento Azul como estrategia europea y el papel del medio marino en el marco de dicha estrategia, con el fin de dibujar un cuadro de referencia para la contextualización de los contenidos temáticos del informe. Seguidamente se realiza un análisis del estado de la técnica, noticias, proyectos y literatura científica.

Por último, se incluyen las fuentes que se han manejado para la realización de este informe.

2. Metodología

La vigilancia tecnológica se entiende como una "forma organizada, selectiva y permanente de captar información del exterior sobre tecnología, analizarla y convertirla en conocimiento para tomar decisiones con menor riesgo y poder anticiparse a los cambios". (AENOR, 2011) Su finalidad última es generar ventajas competitivas para la empresa ya que le proporciona datos para:

Ilustración 1. Finalidad de la Vigilancia Tecnológica

Para el desarrollo de la Vigilancia Tecnológica el primer paso el plantear los aspectos básicos (Degoul, 1992):
¿Cuál es el objeto de la vigilancia? ¿Qué debemos vigilar? ¿Qué información buscar? ¿Dónde localizarla?

Cuando el objetivo de la VT está claramente delimitado, se procede a planificar la estrategia de búsqueda. Para el despliegue de esta fase conviene tener en cuenta que la información puede presentarse de dos formas: estructurada y no estructurada. La primera es propia de las bases de datos, conjuntos de datos homogéneos, ordenados de una forma determinada, que se presenta en forma legible por ordenador (Escorsa, 2001). Su unidad es el registro –o ficha de un artículo científico o una patente- que presenta la información ordenada en campos: autor, título, fecha de publicación, titular de la patente, inventores, etc. En cambio, la información no estructurada se presenta en textos sin un formato determinado (noticias de periódicos, sitios web, blogs, correos electrónicos) cuyo tratamiento requerirá de nuevas herramientas capaces de "leer" y analizar estos textos. Estas herramientas son útiles también para analizar la información de textos completos de artículos

científicos o de patentes. Hoy se considera que el texto es la mayor fuente de información y conocimiento para las empresas. (Escorsa, Pere, Pilar Lázaro Martínez, Círculo de Innovación en Biotecnología, 2007).

Tras la selección de las palabras clave se automatiza la búsqueda en función de las diferentes tipologías de fuentes a utilizar, se lanza la misma y se filtran los resultados en términos de pertinencia, fiabilidad, relevancia, calidad y capacidad de contraste (AENOR, 2011).

Una vez comprobada la calidad de la información, los métodos de análisis han de garantizar su valor para la explotación de los mismos (F. Palop, 1995). El objetivo del análisis es transformar la información en bruto recogida en un producto con alto valor añadido. A partir de aquí, la aportación de los expertos es crítica para crear información avanzada, para generar conocimiento. Pasamos de una masa ingente de información en distintos formatos y lugares a una etapa en la que se captura la información más relevante, se organiza, indexa, almacena, filtra y, finalmente, con la opinión del experto que aporta en este punto del proceso un máximo valor añadido (CETISME, 2003).

A continuación, se incluye un esquema con las distintas fases de la metodología empleada durante la generación de este informe.

Ilustración 2. Fases de la Vigilancia Tecnológica

3. Blue Growth

El crecimiento azul es una estrategia a largo plazo de apoyo al crecimiento sostenible de los sectores marino y marítimo. Reconoce la importancia de los mares y océanos como motores de la economía europea por su gran potencial para la innovación y el crecimiento. Es la contribución de la Política Marítima Integrada (PMI) en la consecución de los objetivos de la Estrategia 2020 para un crecimiento inteligente, sostenible e integrador. La Estrategia consta de tres componentes:

a) Medidas específicas de la Política Marítima Integrada
   - Conocimiento marino para mejorar el acceso a la información sobre el mar;
   - Ordenación del espacio marítimo para garantizar una gestión eficaz y sostenible de las actividades en el mar;
   - Vigilancia marítima integrada para que las autoridades tengan una mejor apreciación de lo que pasa en el mar.

b) Estrategias de cuenca marítima que garanticen la combinación de medidas más adecuada con el fin de fomentar el crecimiento sostenible;

c) Desarrollo de las siguientes actividades específicas:
   - Acuicultura
   - Turismo marítimo, costero y de crucero
   - Biotecnología marina
   - Energía oceánica
   - Explotación minera de los fondos marinos

El informe de vigilancia tecnológica se centra en el desarrollo de plataformas multi uso como solución a varios de los temas prioritarios marcados por la estrategia europea Blue Growth.

4. Estado del arte

A continuación, se describe los dos grandes retos tecnológicos que se abordan en el proyecto:

- Process Mining.
- Monitorización de procesos manuales.

4.1 Process Mining

En los últimos años, el concepto **data science o ciencia de los datos**, ha surgido como una nueva e importante disciplina, que aúna diferentes disciplinas clásicas como pueden ser las bases de datos, estadística, sistemas distribuidos, aprendizaje automático o la minería de datos y de procesos (de Leoni, van der Aalst, & Dees, 2016)[1].

Asimismo, el **concepto de minería de procesos o mining process** forma parte de la ciencia de los procesos (o process science), que es una disciplina más amplia que combina el conocimiento de la tecnología de la información y el conocimiento de las ciencias de gestión para mejorar y ejecutar procesos operativos (Naur, 1974)[2].

Por lo tanto, la **minería de procesos es una disciplina** que aúna técnicas tradicionales de análisis de procesos basadas en datos y análisis basados en eventos. Mientras que los enfoques convencionales de la ciencia de los datos tienden a ser independientes del proceso, en tanto que, las técnicas que se emplean no consideran los modelos de proceso de extremo a extremo; los enfoques de la ciencia de procesos se centran en el proceso y en cómo hacer el modelado, más que en aprender de los eventos (Aalst, 2016)[3]. Por ello, la minería de procesos supone un punto de unión para ambas disciplinas.

Como se ha mencionado, uno de los **objetivos** de la minería de procesos es la de monitorizar y mejorar procesos reales mediante la extracción de registro de eventos disponibles de cualquier sistema actual, por lo que existe una relación entre los procesos actuales y sus datos (eventos) y el modelo del proceso (Wang, Caron, Vanthienen, Huang, & Guo, 2014)[4]. En consecuencia, es necesario (1) extraer u obtener los registros de los eventos, (2) analizarlos y procesarlos mediante minería de datos y análisis de conformidad y (3) a partir de los resultados obtenidos, mejorar el

[1] de Leoni, M., van der Aalst, W., & Dees, M. (2016). A general process mining framework for correlating,predicting and clustering dynamic behavior based on event logs. Information Systems, 235-257

[2] Naur, P. (1974). Concise Survey of Computer Methods. Sweden: Petrocelli

[3] Aalst, W. V. (2016). Process Mining. Data Science in Action. Eindhoven: Springer (Second Edition).

[4] Wang, Y., Caron, F., Vanthienen, J., Huang, L., & Guo, Y. (2014). Acquiring logistics process intelligence: Methdology and an application for a Chinese bulk port. Expert Systems with Applications, 195-209

proceso en cuestión. (Van Eck, Lu, Leemans, & Van der Aalst, 2015)[5], (Van der Aalst W. , 2012)[6].

4.1.1. Técnicas y metodologías

La extracción de eventos es una parte fundamental dentro de la minería de procesos, ya que es la base fundamental. Cabe destacar ciertos aspectos sobre los eventos y su extracción.

En primer lugar, se debe tener en cuenta que los eventos registrados contienen información sobre un único proceso y que están relacionados con una actividad en concreto (Aalst, 2016)[7]. Asimismo, estos eventos deben estar registrados con su fecha y su hora (timestamp o marcas de tiempo).

En segundo lugar, es importante destacar **los diferentes métodos de extracción de eventos** (Van der Aalst & Dustdar, 2012)[8], (Van Eck, Lu, Leemans, & Van der Aalst, 2015)[9], (Ruschel, Alves Portela Santos, & de Freitas Rocha Loures, 2018)[10]. Una vez realizada la extracción de eventos, el siguiente paso es seguir su procesado para la generación del modelo de proceso o mining process. En esta parte, se deben de tener en cuenta diferentes **tipos de minería de procesos:** descubrimiento, conformidad y mejora (Aalst, 2016). El primer proceso es el **descubrimiento**, este utiliza los registros de eventos para crear el modelo del proceso sin utilizar ningún otro tipo de información (Van der Aalst & Dustdar, 2012), mediante diferentes técnicas y algoritmos como son las conocidas redes de Petri, o algoritmos de minería heurística (Weljiters & Ribeiro, 2010)[11] , (Claes & Poels, 2012)[12] e inductivos (Leemans, Fahland, & Van der Aalst, 2013)[13] ,

[5] Van Eck, M., Lu, X., Leemans, S., & Van der Aalst, W. (2015). PM2: A Process Mining Project Methodology. Eindhoven, The Netherlands: Springer.
[6] Van der Aalst, W. (2012). Process Mining Manifesto. Lecture notes in Business information Processing, 169-194
[7] Ver referencia [3].
[8] Van der Aalst, W., & Dustdar, S. (2012). Process Mining Put Into Context. IEEE Internet Computing, 82-86.
[9] Van Eck, M., Lu, X., Leemans, S., & Van der Aalst, W. (2015). PM2: A Process Mining Project Methodology. Eindhoven, The Netherlands: Springer.
[10] Ruschel, E., Alves Portela Santos, E., & de Freitas Rocha Loures, E. (2018). Establishment of maintenance inspection intervals: an application of process mining techniques in manufacturing. Journal of Intelligent Manufacturing.
[11] Weljiters, A., & Ribeiro, J. (2010). Flexible Heuristics Miner (FHM). Beta Working Paper series 334.
[12] Claes, J., & Poels, G. (2012). Process MIning and the ProM Framework: An exploratory survey. Business Process Management Workshops, 187-198.
[13] Leemans, S., Fahland, D., & Van der Aalst, W. (2013). Discovering Block-structured process models from event logs: A constructive approach . Applications and theory of Petri Nets, 311-329.

Leemans, Fahland, & Van der Aalst, Discovering block-structured process models from incomplete event logs, 2014)[14].
El segundo proceso es la verificación de **conformidad**, ésta relaciona eventos en el registro de actividades en el modelo de proceso y hace una comparación entre ambos con el objetivo de encontrar tanto puntos en común, como discrepancias entre el comportamiento modelado y el observado. Finalmente, la mejora del proceso tiene como meta ampliar o mejorar un modelo de proceso ya existente utilizando información sobre el proceso real registrado en algún registro de eventos (Van der Aalst W., 2011)[15] .
También es importante destacar la relación que existe entre la minería de procesos y el aprendizaje automático (machine-learning). La relación viene de la mano de la minería de datos, ya que la minería de datos y el aprendizaje automático son conceptos semejantes (D. Hand, 2001)[16] , (Mitchell, 1997)[17] , (Zaki & Wagner Meira, 2019) [18].

4.1.2. Process mining y VSM

Si hablamos de mejora de procesos y de aplicar metodología lean, no nos debemos de olvidar del concepto **Value Stream Mapping o Mapeo de flujo de valor** (VSM, a partir de ahora). Este concepto fue introducido originalmente por la empresa Toyota como un método de para la mejora el rendimiento de su fabricación. Es una herramienta de visualización que proporciona una representación completa de cómo progresa un trabajo desde el pedido de un cliente hasta el cumplimiento final del pedido o, en términos de industria, desde que el material llega al taller para ser fabricado hasta que finalmente se construye y llega al cliente (Islam Rimon, 2018)[19] . Aun siendo una herramienta muy útil, presenta ciertas limitaciones como su nivel de precisión a la hora de realizar las observaciones y, además, el proceso es un poco estático, por lo que mapear y modelas el comportamiento dinámico de un proceso, le resulta imposible (Balaji, Venkumar, Sabitha, & Amuthaguka, 2020)[20] .

[14] Leemans, S., Fahland, D., & Van der Aalst, W. M. (2014). Discovering block-structured process models from incomplete event logs. Proceedings of the 35th international conference on applications and theory of Petri Nets and COncurrency, 91-110.
[15] Van der Aalst, W. (2011). Process mining: discovery, conformance and enhancement of business processes. Berlin: Springer, 352.
[16] D. Hand, H. M. (2001). *Principles of Data Mining.* Cambridge: MIT Press.
[17] Mitchell, T. (1997). *Machine Learning.* New York: McGraw-Hill.
[18] Zaki, M., & Wagner Meira, J. (2019). *Data Mining and Machine Learning: Fundamental Concepts and Algorithms.* Cambridge University Press.
[19] Islam Rimon, Rafiqul. (2018). Simulation-based Dynamic Value Stream Mapping of a Warehouse Operations.
[20] *Balaji, V., Venkumar, P., Sabitha, M., & Amuthaguka, D. (2020). DVSMS: Dynamic Value Stream Mapping Solution by appying IIoT. Indian Academy of Science.*

En base a todo ello, se ha entendido como una oportunidad la aplicación de la minería de procesos como herramienta de soporte al VSM y así, optimizar y mejorar la productividad de una empresa y, así, eliminar aquellos eventos que no suponen valores añadidos en el proceso de fabricación. De este modo, se utilizarán los diferentes tipos de minería de procesos previamente mencionados (proceso de descubrimiento, mejora y verificación de conformidad) para realizar una primera aproximación de VSM mediante un modelo de proceso, que posteriormente se completa con diferentes métricas para crear un nuevo VSM mejorado.

4.2 Monitorización de procesos manuales

Los **procesos manuales** siguen jugando un papel importante en la industria siendo alguno de ellos clave y difícilmente sustituidos por una máquina debido a su complejidad y/o coste. En los últimos años la **monitorización** de este tipo de proceso se ha centrado en la detección temprana de fallos y errores durante el ensamblaje de componente en cadenas de montaje. Estos sistemas de monitorización en desarrollo se basan en diferentes tecnologías, siendo la sensorización la de mayor potencial.
La opción para la sensorización de este tipo de proceso puede realizarse a través de la colocación de sensores en alguna parte del operario y/o sensorizando sus herramientas[21]. La cinemática de estos elementos puede ser capturad y digitalizada para un posterior procesamiento[22],[23],[24].
Otra alternativa usada en la sensrización de este tipo de proceso es su la combinación sensores con otras tecnologías como pueden ser em **Machine learning o la Realidad Aumentada**.

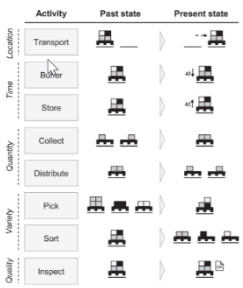
[21] Dalle Mura, M., Dini, G. & Failli, F., 2015. An integrated environment based on augmented reality and sensing device for manual assembly workstations. s.l., 48th CIRP Conference on MANUFACTURING SYSTEMS.
[22] Koskimaki H, Huikari V, Siirtola P, Laurinen P, Roning J. Activity recognition using a wrist-worn inertial measurement unit: a case study for industrial assembly lines. 17th Mediterranean Conference on Control & Automation; 2009.
[23] Hartmann B. Human Worker activity recognition in industrial environments. KIT Scientific Publishing; 2011.
[24] Hartmann B, Schauer C, Link N. Worker behavior interpretation for flexible production. World Academy of Science, Engineering and Technology; 2009

5. Tendencias

A continuación, se citan algunos artículos científicos relacionados con esta temática.

5.1 Literatura científica

Enabling value stream mapping for internal logistics using multidimensional process mining



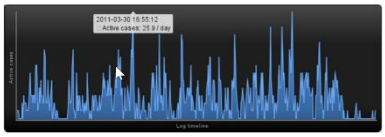
Autor: Knoll, D., Reinhart, G., & Prüglmeier, M.

Publicado en: 2019. *Expert Systems with Applications,124, 130-142.* Doi: 10.1016/j.eswa.2019.01.026

Abstract:
Pen and paper-based value stream mapping (VSM) is the established tool for recording processes, identifying waste and deriving recommendations for action. However, today, its application in manufacturing industry requires a high level of effort and is challenging due to product and process complexity, as well as dynamics. To overcome these shortcomings, we are developing a methodology to apply process mining (PM) to internal logistics for a mixed-model assembly line. The methodology combines multidimensional process mining (MDPM) techniques with proven principles of lean production and VSM. Firstly, internal logistics is modelled using existing event data by automatically mapping physical logistics activities (e.g. transport, store). Secondly, to enable PM, the event data is transformed into enriched event logs. Thirdly, the MDPM approach contains (1) a discovery analysis, (2) a performance analysis and (3) a conformance analysis including a reference process classification for each individual part and process. Finally, a waste analysis and strategy for practitioners is designed to identify and prioritise wasteful parts and processes. The methodology has been applied and evaluated in a case study at a German automotive manufacturer. In the case study, we analysed 7500 parts and 15 reference processes. An analysis for each individual part and process has not been available yet. We could both identify part-specific root causes (e.g. a long lead time) and process-specific root causes (e.g. a low trace fitness). The main contribution of this paper is to provide an MDPM methodology for practitioners to

enable a continuous recording, evaluation and waste analysis of each individual part and process within internal logistics.

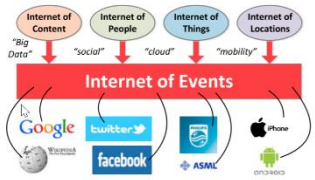
Acquiring logistics process intelligence: Methodology and an application for a Chinese bulk port



Autor: Wang, Y., Caron, F., Vanthienen, J., Huang, L., & Guo, Y.
Publicado en: 2014. Expert Systems with Applications, 41(1), 195-209. *10.1016/j.eswa.2013.07.021*

Abstract:
Pen and paper-based value stream mapping (VSM) is the established tool for recording processes, identifying waste and deriving recommendations for action. However, today, its application in manufacturing industry requires a high level of effort and is challenging due to product and process complexity, as well as dynamics. To overcome these shortcomings, we are developing a methodology to apply process mining (PM) to internal logistics for a mixed-model assembly line. The methodology combines multidimensional process mining (MDPM) techniques with proven principles of lean production and VSM. Firstly, internal logistics is modelled using existing event data by automatically mapping physical logistics activities (e.g. transport, store). Secondly, to enable PM, the event data is transformed into enriched event logs. Thirdly, the MDPM approach contains (1) a discovery analysis, (2) a performance analysis and (3) a conformance analysis including a reference process classification for each individual part and process. Finally, a waste analysis and strategy for practitioners is designed to identify and prioritise wasteful parts and processes. The methodology has been applied and evaluated in a case study at a German automotive manufacturer. In the case study, we analysed 7500 parts and 15 reference processes. An analysis for each individual part and process has not been available yet. We could both identify part-specific root causes (e.g. a long lead time) and process-specific root causes (e.g. a low trace fitness). The main contribution of this paper is to provide an MDPM methodology for practitioners to enable a continuous recording, evaluation and waste analysis of each individual part and process within internal logistics.

Data science in action.

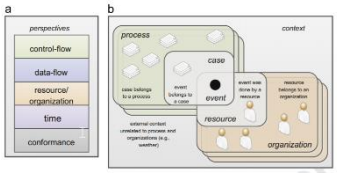


Autor: Van Der Aalst, W.

Publicado en: 2016. Process mining (pp. 3-23). DOI: 10.1007/978-3-662-49851-4_1

Abstract:
In recent years, data science emerged as a new and important discipline. It can be viewed as an amalgamation of classical disciplines like statistics, data mining, databases, and distributed systems. Existing approaches need to be combined to turn abundantly available data into value for individuals, organizations, and society. Moreover, new challenges have emerged, not just in terms of size ("Big Data") but also in terms of the questions to be answered. This book focuses on the analysis of behavior based on event data. Process mining techniques use event data to discover processes, check compliance, analyze bottlenecks, compare process variants, and suggest improvements. In later chapters, we will show that process mining provides powerful tools for today's data scientist. However, before introducing the main topic of the book, we provide an overview of the data science discipline.

A general process mining framework for correlating, predicting and clustering dynamic behavior based on event logs



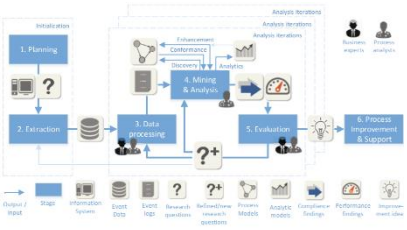
Autor: De Leoni, M., van der Aalst, W. M., & Dees, M.

Publicado en: 2016. Information Systems, 56, 235-257. DOI: 10.1016/j.is.2015.07.003

Abstract:
Process mining can be viewed as the missing link between model-based process analysis and data-oriented analysis techniques. Lion's share of process mining research has been focusing on process discovery (creating process models from raw data) and replay techniques to check conformance and analyze bottlenecks. These techniques have helped organizations to address compliance and performance problems. However, for a more refined analysis, it is essential to correlate different process characteristics. For example, do deviations from the normative process cause additional delays and costs? Are rejected cases handled differently in the initial phases of the process? What is the influence of a doctor's experience on treatment process? These and other questions may involve process characteristics related to different

perspectives (control-flow, data-flow, time, organization, cost, compliance, etc.). Specific questions (e.g., predicting the remaining processing time) have been investigated before, but a generic approach was missing thus far. The proposed framework unifies a number of approaches for correlation analysis proposed in literature, proposing a general solution that can perform those analyses and many more. The approach has been implemented in ProM and combines process and data mining techniques. In this paper, we also demonstrate the applicability using a case study conducted with the UWV (Employee Insurance Agency), one of the largest "administrative factories" in The Netherlands.

PM2: A Process Mining Project Methodology



Autor: van Eck, M. L., Lu, X., Leemans, S. J., & van der Aalst, W. M.
Publicado en: International Conference on Advanced Information Systems Engineering (pp. 297-313). Springer, Cham. DOI: 10.1007/978-3-319-19069-3_19

Abstract:
Process mining aims to transform event data recorded in information systems into knowledge of an organisation's business processes. The results of process mining analysis can be used to improve process performance or compliance to rules and regulations. However, applying process mining in practice is not trivial. In this paper we introduce PM 2 , a methodology to guide the execution of process mining projects. We successfully applied PM 2 during a case study within IBM, a multinational technology corporation, where we identified potential process improvements for one of their purchasing processes.

Process mining put into context

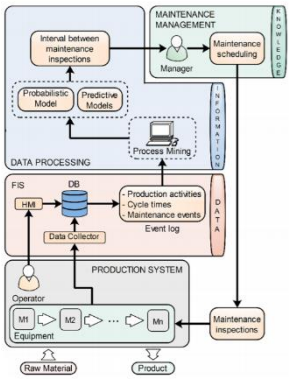
Autor: Van Der Aalst, W. M., & Dustdar, S.

Publicado en: 2012. IEEE Internet Computing, 16(1), 82-86. DOI: 10.1109/MIC.2012.12

Abstract:
Process mining techniques help organizations discover and analyze business processes based on raw event data. The recently released "Process Mining Manifesto" presents guiding principles

and challenges for process mining. Here, the authors summarize the manifesto's main points and argue that analysts should take into account the context in which events occur when analyzing processes.

Establishment of maintenance inspection intervals: an application of process mining techniques in manufacturing



Autor: Ruschel, E., Santos, E. A. P., & Loures, E. D. F. R.

Publicado en: 2020. ournal of Intelligent Manufacturing, 31(1), 53-72. DOI: 10.1007/s10845-018-1434-7

Abstract:

Reducing costs and increasing equipment availability (uptime) are among the main goals of industrial ventures. Well defined interval durations between maintenance inspections provide major support in achieving these targets. However, in order to establish the best interval length, process behavior, cycle times and related costs must be clearly known, and future estimates for these parameters must be established. This paper applies process mining techniques in developing a probabilistic model in Bayesian Networks integrated to predictive models. The probability of a given activity occurring in the probabilistic model output establishes the forecast boundaries for predictive models, responsible for estimating process cycle times. Availability (uptime) and cost functions are mathematically defined and an iterative process is performed in the length of intervals between maintenance inspections until the time and costs wasted are minimized and the best interval duration is found. The probabilistic model enables simulating changes in the event occurrence probability, allowing a number of different scenarios to be visualized and providing better support to managers in scheduling maintenance activities. The results show that production losses can be further reduced through optimally defined intervals between maintenance inspections.

Flexible heuristics miner (FHM)

Autor: Weijters, A. J. M. M., & Ribeiro, J. T. S.

Publicado en: 2011. IEEE symposium on computational intelligence and data mining (CIDM) (pp. 310-317). IEEE.DOI: 10.1109/CIDM.2011.5949453

Abstract:
One of the aims of process mining is to retrieve a process model from a given event log. However, current techniques have problems when mining processes that contain nontrivial constructs, processes that are low structured and/or dealing with the presence of noise in the event logs. To overcome these problems, a new process representation language is presented in combination with an accompanying process mining algorithm. The most significant property of the new representation language is in the way the semantics of splits and joins are represented; by using so-called split/join frequency tables. This results in easy to understand process models even in the case of non-trivial constructs, low structured domains and the presence of noise. This paper explains the new process representation language and how the mining algorithm works. The algorithm is implemented as a plug-in in the ProM framework. An illustrative example with noise and a real life log of a complex and low structured process are used to explicate the presented approach.

Process mining and the ProM framework: an exploratory survey

Autor: Claes, J., & Poels, G.

Publicado en: 2012. International Conference on Business Process Management (pp. 187-198). Springer, Berlin, Heidelberg. DOI: 10.1007/978-3-642-36285-9_19

Abstract:
In the last decade the field of process mining gained attention from research and practice. There is, however, not much known about the use and the appreciation of the involved techniques and tools, many of which are integrated into the well-known ProM framework. Therefore a questionnaire was sent out to ask people's opinions about process mining and the ProM framework. This paper reports on the answers and tries to link them to existing knowledge from academic literature and popular articles. It must be seen as a first, exploratory attempt to reveal the adoption of process mining and the actual use of the ProM framework..

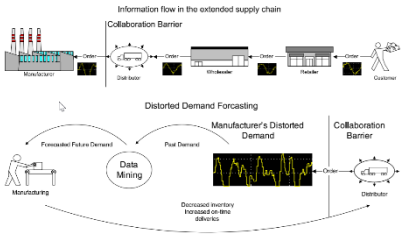
Discovering block-structured process models from event logs-a constructive approach

Autor: Leemans, S. J., Fahland, D., & van der Aalst, W. M.

Publicado en: 2013. International conference on applications and theory of Petri nets and concurrency (pp. 311-329). Springer, Berlin, Heidelberg. DOI: 10.1007/978-3-642-38697-8_17

Abstract:
Process discovery is the problem of, given a log of observed behaviour, finding a process model that 'best' describes this behaviour. A large variety of process discovery algorithms has been proposed. However, no existing algorithm guarantees to return a fitting model (i.e., able to reproduce all observed behaviour) that is sound (free of deadlocks and other anomalies) in finite time. We present an extensible framework to discover from any given log a set of block-structured process models that are sound and fit the observed behaviour. In addition we characterise the minimal information required in the log to rediscover a particular process model. We then provide a polynomial-time algorithm for discovering a sound, fitting, block-structured model from any given log; we give sufficient conditions on the log for which our algorithm returns a model that is language-equivalent to the process model underlying the log, including unseen behaviour. The technique is implemented in a prototypical tool.

Application of machine learning techniques for supply chain demand forecasting



Autor: Carbonneau, R., Laframboise, K., & Vahidov, R.

Publicado en: 2008. European Journal of Operational Research, 184(3), 1140-1154. DOI: 10.1016/j.ejor.2006.12.004

Abstract:
Full collaboration in supply chains is an ideal that the participant firms should try to achieve. However, a number of factors hamper real progress in this direction. Therefore, there is a need for forecasting demand by the participants in the absence of full information about other participants' demand. In this paper we investigate the applicability of advanced machine learning techniques, including neural networks, recurrent neural networks, and support vector machines, to forecasting distorted demand at the end of a supply chain (bullwhip effect). We compare

these methods with other, more traditional ones, including naïve forecasting, trend, moving average, and linear regression. We use two data sets for our experiments: one obtained from the simulated supply chain, and another one from actual Canadian Foundries orders. Our findings suggest that while recurrent neural networks and support vector machines show the best performance, their forecasting accuracy was not statistically significantly better than that of the regression model.

Big data analytics for physical internet-based intelligent manufacturing shop floors

Autor: Zhong, R., Xu, C., Chen, C., & Huang, G.

Publicado en: 2015. International journal of production research, 55(9), 2610-2621. DOI: 10.1080/00207543.2015.1086037

Abstract:
Physical Internet (PI, π) has been widely used for transforming and upgrading the logistics and supply chain management worldwide. This study extends the PI concept into manufacturing shop floors where typical logistics resources are converted into smart manufacturing objects (SMOs) using Internet of Things (IoT) and wireless technologies to create a RFID-enabled intelligent shop floor environment. In such PI-based environment, enormous RFID data could be captured and collected. This study introduces a Big Data Analytics for RFID logistics data by defining different behaviours of SMOs. Several findings are significant. It is observed that task weight is primarily considered in the logistics decision-making in this case. Additionally, the highest residence time occurs in a buffer with the value of 12.17 (unit of time) which is 40.57% of the total delivery time. That implies the high work-in-progress inventory level in this buffer. Key findings and observations are generated into managerial implications, which are useful for various users to make logistics decisions under PI-enabled intelligent shop floors.

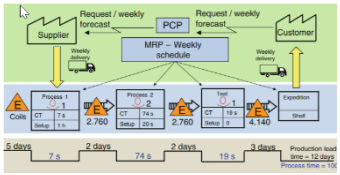
Simulation-based Dynamic Value Stream Mapping of a Warehouse Operations

Autor: Von Islam Rimon, R.

Publicado en: 2018. Universität Duisburg-Essen

Abstract:
The main objective of the lean concept is to eliminate waste from an organization and improve organization's overall activity efficiency. Value stream mapping is a tool widely used after Toyota has developed this to improve its production efficiency. VSM first designs a current state map of an organization to identify waste and develop plans to eliminate this waste. This paper will focus on a simulation-based value stream mapping of a warehouse. Since warehouses facing many problems regarding its holdings on inventory in the supply chain and fulfill demand in time, warehouse faces many uncertainties in its function. Therefore, it is important to recognize this problem and develop a methodology to eliminate such problem must be made. This thesis describes the Lean concept, particularly Value Stream Mapping tool to a warehouse context and introducing methods & guideline to use simulation to model a dynamic value stream map. A simulation-based value stream map will make a difference of an uncertain VSM with a dynamic system. Simulation practice to design DVSM will demonstrate how warehouse activity behaves on certain changes in demand over time. A simulation model for dynamic VSM is not limited to be used only in warehouse facility but the methods described in this thesis can be used in any other organization that wants to understand how the system behaves over changes and identify waste in the process and improves the overall system outcome.

Value Stream Mapping: a study about the problems and challenges found in the literature from the past 15 years about application of Lean tools.



Autor: Dal Forno, A. J., Pereira, F. A., Forcellini, F. A., & Kipper, L. M

Publicado en: 2014. The International Journal of Advanced Manufacturing Technology, 72(5-8), 779-790.Int. J. Sci. Technol. Soc, 3, 6-10. DOI: 10.1007/s00170-014-5712-z

Abstract:
Value stream mapping (VSM) is an important tool of the lean approach and is used to identify value-adding activities and those considered wasteful of materials and the flow of information and people. However, when not applied correctly, VSM can complicate the identification of waste, lead to misinterpretations and assessment mistakes, and undermine the implementation of future improvements. The purpose of this paper is to investigate the main difficulties and limitations encountered during the construction of current state maps, analysis of the associated causes, and pointing out of guidelines to facilitate the use of VSM to map processes. To do so, a search and evaluation of papers in journals, conferences, theses, and dissertations was conducted, and the articles were categorized according to the field of application (factory floor, supply chain, product development and services) and approach (theoretical or practical). In conclusion, this paper criticizes some ways that VSM has been used, observing that important constraints created by its application must be considered and that when used incorrectly, the tool can lead to mistakes that can cause problems instead of benefits. Considering the problems identified, the paper suggests future works for improving the use of VSM for mapping processes.

An evaluation of the value stream mapping tool

Autor: Lasa, I. S., Laburu, C. O., & de Castro Vila, R.

Publicado en: 2008. Business process management journal. DOI: 10.1108/14637150810849391

Abstract:
Purpose
The value stream mapping (VSM) is a tool created by the lean production movement for redesigning the productive systems. Since, it was theoretically developed, some cases have been

published where the mentioned tool has been used; however, there is a need to see how it is put into practice, that is to analyze the level in which theory is able to adapt to real practice, the strengths, weaknesses and the key aspects to be taken into account by the applicant teams to obtain the highest performance of the VSM. This paper aims to discuss all of these aspects.

Design/methodology/approach
The methodology used is a case study of a company in which the process of application of the VSM has been thoroughly analyzed. A team created to improve the productive system of a manufacture for plastic casings for mobile phones has carried out this application.

Findings
The research shows that the VSM is a valuable tool for redesigning the productive systems according to the lean system. Nevertheless, there are some key points for the establishing teams that have to take into account, as follows: the time and training resources spent, the use of suitable information systems and a suitable management of the application phases.

Research limitations/implications
The conclusions of this research can be reinforced by the monitoring of the application process in more company cases.

Practical implications
The conclusions of this research are useful for future practitioners, so that they may bear in mind the different aspects of planning projects for redesigning productive systems by using VSM. On the other hand, these conclusions can also be useful for the academic field in order to enhance the theory of VSM.

Originality/value
The paper is a contribution based on practical references according to a thoroughly monitoring of a successful case in establishing VSM.

A cross-sector review on the use of value stream mapping

Autor: Von Islam Rimon, R.

Publicado en: 2017. International Journal of Production Research, 55(13), 3906-3928. DOI: 10.1080/00207543.2017.1311031

Abstract:
Value Stream Mapping (VSM) has become a popular method for lean thinking and implementation in recent years. Previous reviews related to VSM are limited to individual sectors due to varied research objectives. The lack of studies which focus on cross-sector review of VSM studies is impeding the implementation of VSM by both lean researchers and practitioners. The paper aims to determine the-state-of-the-art development of VSM in five sectors, including manufacturing, health care, construction, product development and service sectors. A total of 131 journal articles are reviewed and analysed from the period of 1999–12/2016. The analysis covers the complete implementation cycle of VSM, including metrics for current state map, improvement techniques for future state map, benefits and achievements of VSM application, and critical success factors for VSM implementation. Cross-sector comparisons and investigations are conducted to understand the differences of VSM implementations in various sectors to facilitate VSM development and increase the number of successful VSM implementation. The results suggest that understanding value and waste in a diverse value stream environment and ensuring the suitability and usability of traditional lean metrics/techniques within the different flow settings are central to the VSM development.

DVSMS: dynamic value stream mapping solution by applying IIoT

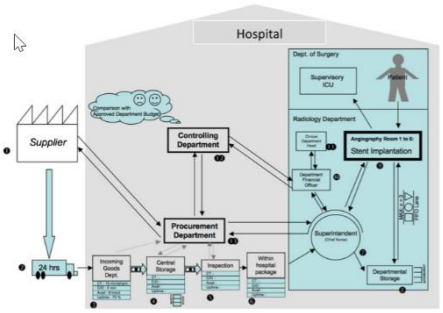
Autor: DVSMS: dynamic value stream mapping solution by applying IIoT.

Publicado en: 2020. Sādhanā, 45(1), 38. DOI: 10.1007/s12046-019-1251-5

Abstract:
The purpose of any business is to delight the customer as a primary stakeholder, thereby enhancing the growth and profitability. Understanding customer needs and building them on end to end value chain not only will result in serving customers on time, but also improve the effectiveness of the processes to

retain competitiveness. Value stream mapping remains a popular visualization tool in the hands of the Lean Manager who seeks to produce more with less. However, value stream mapping (VSM) tends to be static and skill dependent. With the advent of Industrial Internet of Things (IIoT), there could be a paradigm shift on how VSM could be leveraged for maximizing results. IIoT makes it possible to convert the VSM as a dynamic one, enhancing with several additional parameters measured simultaneously in real time, making the relationship between cause and effect more visible. Literally, with the addition of IIoT, we could digitally re-live the moments from the past to identify the connections between the cause and effect more specifically with better accuracy. In this paper, we attempt to clarify how IIoT could enhance the VSM as a strategic differentiator for making better decisions. In a sensor-based efficiency monitoring system, the VSM becomes dynamic; thereby all the parameters including the bottleneck operations could be continuously monitored and acted upon to attain the future state eliminating the dependency on the expertise of the people.

Applying value stream mapping techniques to eliminate non-value-added waste for the procurement of endovascular stents



Autor: Teichgräber, U., & de Bucourt, M.

Publicado en: 2012. Teichgräber, U. K., & de Bucourt, M. DOI: 10.1016/j.ejrad.2010.12.045

Abstract:

Objectives

To eliminate non-value-adding (NVA) waste for the procurement of endovascular stents in interventional radiology services by applying value stream mapping (VSM).

Materials and methods

The Lean manufacturing technique was used to analyze the process of material and information flow currently required to direct endovascular stents from external suppliers to patients. Based on a decision point analysis for the procurement of stents in the hospital, a present state VSM was drawn. After assessment

of the current status VSM and progressive elimination of unnecessary NVA waste, a future state VSM was drawn.

Results
The current state VSM demonstrated that out of 13 processes for the procurement of stents only 2 processes were value-adding. Out of the NVA processes 5 processes were unnecessary NVA activities, which could be eliminated. The decision point analysis demonstrated that the procurement of stents was mainly a forecast driven push system. The future state VSM applies a pull inventory control system to trigger the movement of a unit after withdrawal by using a consignment stock.

Conclusion
VSM is a visualization tool for the supply chain and value stream, based on the Toyota Production System and greatly assists in successfully implementing a Lean system.

Application of dynamic value stream mapping in warehousing context

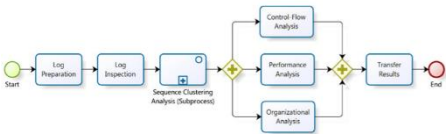
Autor: Abdoli, S., Kara, S., & Kornfeld, B.

Publicado en: 2017. Modern Applied Science, 11(1), 1913-1852. DOI: 10.5539/mas.v11n1p76

Abstract:
Uncertainty within supply chains increases the risk of not meeting objectives. Warehouses can absorb some of these uncertainties, by accumulating inventory. This accumulation has led many to consider warehouses as a source of waste in supply chains. Hence, there is limited research that seeks improving intrinsic warehouse efficiency; particularly in the context of Lean concepts and Value Stream Mapping (VSM). Since, warehouses seek to absorb uncertainty in supply chain by holding inventory; this uncertainty absorption may introduce variability to warehousing function itself. Therefore a methodology is required, which can capture the embodied dynamic within warehousing function. This paper reflects Lean concepts and, in particular, VSM to warehousing context and introduces some methods and guidelines to assure the proper application of VSM in what is an uncertain and dynamic system. In this paper, warehousing function is formulated based on some abstract processes which vary on their output status. This formulation facilitates identifying

value-adding activities as one of the most substantial steps, yet confusing in application of VSM in warehousing context. The suggested methods enable fundamental statistical/mathematical analysis, which leverage VSM to a more dynamic evaluation tool. Application of the introduced approach will facilitate the decision making process for warehouse systems evaluation and improvement. The resultant methodology is applied to a factual case and this serves to demonstrate its practical application. It is worth mentioning that the findings applications, which can be termed 'dynamic VSM', are not limited to warehouses but can also be applied to any dynamic environment with non-deterministic processes.

Business process analysis in healthcare environments: A methodology based on process mining.



Autor: Rebuge, Á., & Ferreira, D. R.

Publicado en: 2012. Information systems, 37(2), 99-116.DOI: 10.1016/j.is.2011.01.003

Abstract:
Performing business process analysis in healthcare organizations is particularly difficult due to the highly dynamic, complex, ad hoc, and multi-disciplinary nature of healthcare processes. Process mining is a promising approach to obtain a better understanding about those processes by analyzing event data recorded in healthcare information systems. However, not all process mining techniques perform well in capturing the complex and ad hoc nature of clinical workflows. In this work we introduce a methodology for the application of process mining techniques that leads to the identification of regular behaviour, process variants, and exceptional medical cases. The approach is demonstrated in a case study conducted at a hospital emergency service. For this purpose, we implemented the methodology in a tool that integrates the main stages of process analysis. The tool is specific to the case study, but the same methodology can be used in other healthcare environments.

5.2 Proyectos

New, Advanced and Value-Added Innovative Ships

Financiado por: Horizon 2020

Periodo de financiación: 2018-2022

+ INFO

Resumen:

The European maritime technology sector generates an annual turnover of € 112.5 billion and creates more than 500,000 direct jobs and more than 400,000 indirect jobs, primarily for European citizens. However, worldwide competition is fierce, and in order to maintain world-leadership in complex, value-added and highly specialised vessels European shipbuilders must develop tailor-made innovative concepts that are efficient to design and build. NAVAIS develops a platform-based modular product family approach supported by the 3DEXPERIENCE® integrated business platform. This concept will increase efficiency in vessel design and flexibility in production networks. NAVAIS focusses on passenger/road ferries and multi-use workboats integrating sustainability in the design of the ships.

NAVAIS supports the transfer from an engineered-to-order business model to an assemble-to-order business model, which allows shorter process lead-times, constant quality, reduced design and production costs and better integration of the SME supply chain, thereby increasing competitiveness of the European shipbuilding industry…

LINCOLN

Financiado por: Horizon 2020

Periodo de financiación: 2016/2019

+ INFO

Resumen:

The global challenges, such as climate changes, green energy, food security, people safety and migrants mobility, and the new technological developments are reshaping the European

economy, affecting the usage of the marine space as well. In the last decades, new business activities were born along the European seacoasts, such as aquaculture and renewable energy, beside the intensification of more traditional ones, like blue tourism, surveying, emergency and recovery response. This marine business diversification brings new activities and requires specialized operations and then the maritime industry is challenged to develop innovative vessels able to work in a more and more efficient, cost effective and specialized way to satisfy the above business needs. LINCOLN project demonstrates how this new market demand of the maritime sector can be satisfied through an integrated approach among the technological enhancements in the vessels equipment and ICT sector, a new design & shipbuilding proposition and the vessel life cycle perspective adoption. This adds high value not only to the vessels in themselves, but to the whole shipbuilding industry and its value chain.

LINCOLN project vision is to develop three new added value vessels with innovative on-board equipment, using lean design methodology and IoT solutions, able to be used in diverse maritime coastal activities and sectors in an efficient and sustainable way. The new developed vessels are:

- A multi-platform catamaran to serve as Service crew vessel and Multipurpose survey vessel, with hybrid propulsion and innovative people transfer system
- A design and production module based high-speed patrol boat platform, with its first vessel release
- An Emergency Response and Recovery Vessel (ERRV), with a low-cost dynamic positioning system.

These vessels represent three highly focused costal activities and takes in account all the main seas around Europe (Atlantic Ocean, North Sea, Mediterranean).

HOLIstic optimisation of SHIP design and operation for life cycle

Financiado por: Horizon 2020

Periodo de financiación: 2016/2020

+ INFO

Resumen:

The face of ship design is changing. The vastly increasing complexity of European built ships and maritime structures as well as the growing number of rules and regulations call for novel concepts of product design and testing. HOLISHIP develops the next generation of ship design systems for the European maritime industry by addressing urgent problems of today's ship design practice, which consider future requirements and challenges by introducing a novel holistic ship design concept for life cycle.

Most maritime assets (ships and marine structures) are typically associated with large investments and are seldom built in large series. Where the automotive, rail and aircraft industry benefit from the economy of series production, this is not the case for maritime structures which are typically designed to refined customer requirements increasingly determined by the need for high efficiency, flexibility, and low environmental impact at a competitive price. In the maritime field, product design is thus subject to global trade-offs among traditional constraints (customer needs, technical requirements, cost) and new requirements such as life-cycle cost, environmental impact, enhanced safety rules. One of the most important design objectives is to minimise the life-cycle cost, taking into account maintenance, refitting, renewal, manning, recycling, environmental footprint, etc. The trade-off among all these requirements must be assessed and evaluated efficiently and reliably in the first steps of the design process on the basis of customer / owner specifications.

The above requirements, constraints and objectives call for novel design tools including multi-objective optimisation and virtual testing of the overall design and its components as well as its economic and ecologic impact. HOLISHIP addresses these

urgent industrial and societal needs by the development of innovative design methodologies and tools that can be employed already at an early design stage, while looking for the entire life-cycle in an integrated design environment. The introduced holistic concept is implemented in integrated design s/w platforms and allows the exploration of the huge design space in comparatively short lead times. The HOLISHIP design approach is demonstrated by digital mock-ups and a large range of industry led application studies on the design and performance of ships maritime structures.

Disruptive Digital Twin solution combining sensor data streams and high accuracy physics-based models to design and monitor large structural assets

Financiado por: Horizon 2020

Periodo de financiación: 2018

+ INFO

Resumen:

Akselos Integra is seeing great commercial success in the Oil & Gas industry. The overall goal of the project is to ensure that Akselos Integra reaches the adequate maturity not only for a successful market entry in a new vertical but also for guaranteed industry competitiveness. To achieve this, we studied the overall market (and target market verticals) to better understand needs for a successful implementation in a new vertical and also determined the technical features required to meet these needs.

DTY – Digital Twin Yard

Financiado por: MAROFF-2 Maritim Virksomhet og offsh-2

Periodo de financiación: 2019/2021

+ INFO

Resumen:

The grand vision of the Digital Twin Yard (DTYard) is to establish a maritime industry ecosystem for models and digital twin system simulations. The DTYard will facilitate efficient and effective construction of digital twin systems and ships in a collaborative

effort between stakeholders including owner, yard, equipment manufacturers and sub-suppliers.

The DTYard includes a model library where the maritime industry can share their models and digital twin components with other stakeholders while keeping their Intellectual Property (IP) concealed and source code protected. The digital twin ship will be constructed from a large set of models and digital twin components of the ship's equipment and automation systems, all interfaced and connected as they would be on-board the real ship. This can be viewed as a virtual yard for assembling models and subsystems into systems and entire vessels. The library and virtual yard will be supported by a new standard for maritime models and simulation, enabling efficient exchange and connection of models. The Digital Twin Yard further contains simulation infrastructure to perform efficient and smart system simulations for a wide range of purposes and scenarios.

The DTYard ecosystem will enable a wide use of digital twin systems and ships in the maritime industry, and help solve the increasing challenges in designing, building, integrating, commissioning, operating and assuring complex, integrated systems and software.

5.3 Noticias

Using digital twins for knowledge transfer

Publicado en: Techxplore

Fecha: 01/07/2020

Gathering with customers and colleagues at meetings, events, workshops and seminars and collaborating with them in person has always been important—but it is not an option for the foreseeable future. The coronavirus pandemic is forcing us to find new ways of working together. The Fraunhofer Institute for Industrial Engineering IAO and the Fraunhofer Institute for Manufacturing Engineering and Automation IPA have already developed solutions to enable remote communication in tomorrow's work scenarios. Cooperation with their partners from industry and research is shifting to the digital Future Work Lab run by the two Stuttgart-based institutes—a solution that crosses

boundaries and borders. This new form of connectivity is made possible by digital twins and virtual lab tours…

Ver noticia

A Global digital twins market to grow six-fold by 2026 says new report

Publicado en: Power Ingineering International

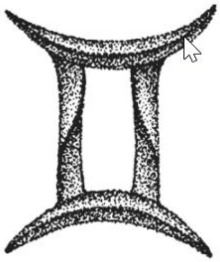
Fecha: 17/07/2020

The global digital twin market in the utility industry is expected to grow more than six-fold between 2020 and 2026 and increase in value from $2.69 billion in 2019 to $9.35 billion, according to a new report.

The research states that major players have begun to deliver goods and solutions following global coronavirus lockdown conditions…

Ver noticia

Creating complex digital twins requires sharing intellectual property



Publicado en: Yale Environment 360

Fecha: 08/06/2020

Digital-twin technology is attractive to businesses trying to get the most out of their physical assets and increasingly to organisations attempting a systematic study of complex systems, such as smart cities and oil-and-gas supply chains.

The announcement last month of the Digital Twin Consortium is an attempt to make digital twin technology more powerful and usable than ever before, through addressing one of the key problems slowing down its development: interoperability. The consortium is an open-standards organization under the

auspices of the Object Management Group, backed by Microsoft, Dell, Ansys and Lendlease, among many others…

Ver noticia

The Virtual Experience Twin is at the heart of the Naval Industry Renaissance

Publicado en: Defence Connect

Fecha: 22/01/2020

Virtual experience twins combine real-time operational data with 3D models, simulation and analytics, offering a single source of digital truth and enabling stakeholders across the naval shipbuilding value chain to define, simulate, validate, plan, predict and execute flawlessly at every stage of naval shipbuilding. This allows shipyards to reduce costs, boost efficiency, and improve safety throughout the vessel's lifecycle.

The world is experiencing a profound global transformation in the way we invent, learn, produce and trade. It is reshaping industries by connecting the virtual world and the real world. It is as great a change as the Renaissance that occurred in Europe from the 14th to the 16th century…

Ver noticia

6. Normativa

A continuación, se cita la normativa relacionada con la tecnología del gemelo digital:

- **ISO 17599**: General requirements of digital mock-up for mechanical products.
- **NATO Standard-ANEP 84**: Standards for virtual ships
- **ISO/CD 23247-1**: Digital Twin manufacturing framework — Part 1: Overview and general principles. *Under development*
- **ISO/CD 23247-2**: Digital Twin manufacturing framework — Part 2: Reference architecture. *Under development*
- **ISO/CD 23247-3**: Digital Twin manufacturing framework — Part 3: Digital representation of physical manufacturing elements. *Under development*
- **ISO/CD 23247-4**: Digital Twin manufacturing framework — Part 4: Information exchange. *Under development*
- **ISO/CD TR 24464**: Visualization elements of digital twins. *Under development*

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