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Improved Data Fusion in Digital Twins: A Requirements Analysis

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Overview

- Digital Twins in Defense
- Data Fusion Techniques
- Requirements
- Path Forward

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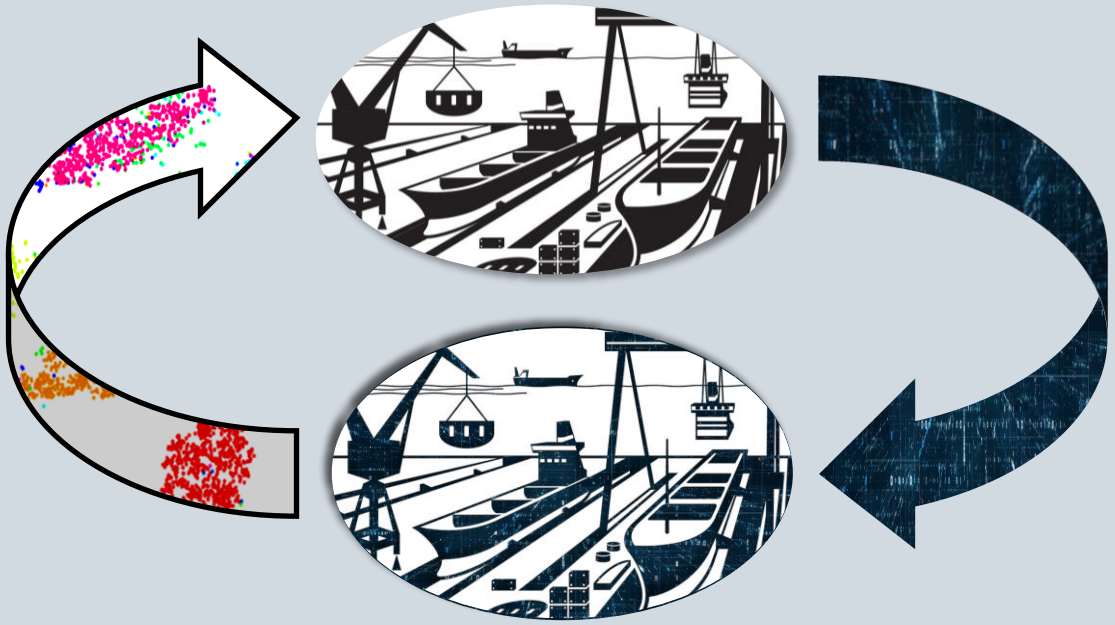
Digital Twins (DTs)

Digital instantiation of a physical system with synchronized, bidirectional data sharing

- Modeling and Simulation
- Integration and Test
- Maintenance
- Optimization



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DTs in US Defense Industry

applied sciences

MDPI

Article

Developing a Digital Twin and Digital Thread Framework for an 'Industry 4.0' Shipyard

Toh Yen Pang [1,*], Juan D. Pelaez Restrepo [1], Chi-Tsun Cheng [1]

Navy Optimizing Shipyards With Digital Twin Technology

BY YASMIN TADJDEH

The Navy's public shipyards — which repair the service's submarines and aircraft carriers — are aging and facing obsolescence issues. To revitalize the yards and improve infrastructure, the Navy is in the midst of a multi-billion-dollar optimization overhaul that will employ digital twin technology to map out areas most in need of changes.

The Shipyard Infrastructure Optimization Program, or SIOP, is a 20-year, $21-billion effort to modernize the four public yards in Norfolk, Virginia; Pearl Harbor, Hawaii; Portsmouth, Virginia; and Puget Sound, Washington.

"We've got dry docks that are over 100 years old," said Steve Lagana, program manager for the SIOP office. "We have buildings that are over 100 years old."

Rep. Rob Wittman, R-Va., ranking member of the House Armed Services subcommittee on seapower and projection forces, said the yards are in dire need of an upgrade.

"When you travel to our public shipyards, it is sobering to see the age of the dry docks, … the limited capability of the dry docks, and also the age of the shops that are there," he said during the Surface Navy Association's annual conference in January, which was held virtually due to the COVID-19 pandemic.

This creates substantial efficiency issues, he noted.

"If you go to a place like Norfolk Naval Shipyard, and you're working on ture is intrinsically linked to performance and in 2017 began laying the groundwork for the SIOP program, which officially began in the summer of 2018, Lagana said.

"This really is an … industrial manufacturing optimization program with a focus on productivity in the shipyards and how that affects the overall national defense," he said. "How do we get submarines in and out of shipyards as efficiently as possible, so the fleet commanders have the assets they need to do their mission?"

Critical to the effort is a modeling-and-simulation technology known as digital twins which digitally replicates an object, place or building, said Stephanie Douglas, executive director for logistics, maintenance and industrial operations at Naval Sea Systems Command.

"The modeling and simulation is really key as it allows us the opportunity to figure out how to optimize flow, not only within the shops, but around the yards to provide the most efficient and productive layout for operations within the shipyard," she said. "We're already seeing some really exciting things come out of the modeling-and-simulation piece of it in terms of opportunities."

The service reached out to fication of that, we will start into that effort," he said.

Norfolk is also moving along well, he added.

Lagana noted that all the yards will have their digital twins up and running this year.

The service is already gleaning a great deal of information from Pearl Harbor's digital twin, he said.

"We're definitely getting some better insight into some potential tweaks in infrastructure," he said. "With any analysis, you kind of want to find that sweet spot, that knee in the curve to where can I get the most efficiencies with the best return on investment."

In some cases, the Navy is finding that

The Los Angeles-class fast-attack submarine USS Olympia arrives at Puget Sound Naval Shipyard.

- Naval Shipyards
- Intrusion Detection Control Systems
- Antisubmarine Warfare Sensors
- Cybersecurity Initiatives

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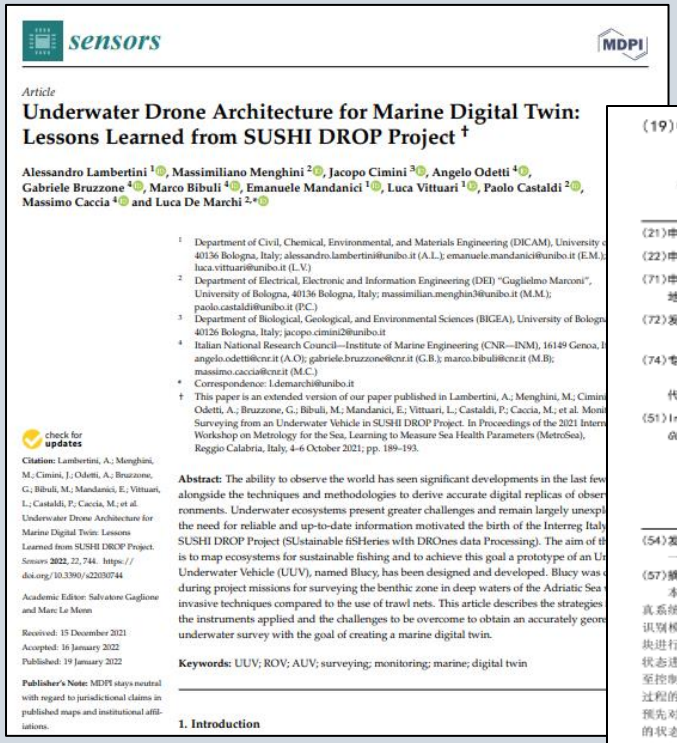
Global Defense Instantiations of DTs

- **Italy** – Researching underwater drone digital twins
- **China** – Filed patent for shipyard digital twin architecture
- **Russia** – Promoting digital twin use within the Russian military-industrial complex



sensors

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Article

Underwater Drone Architecture for Marine Digital Twin: Lessons Learned from SUSHI DROP Project †

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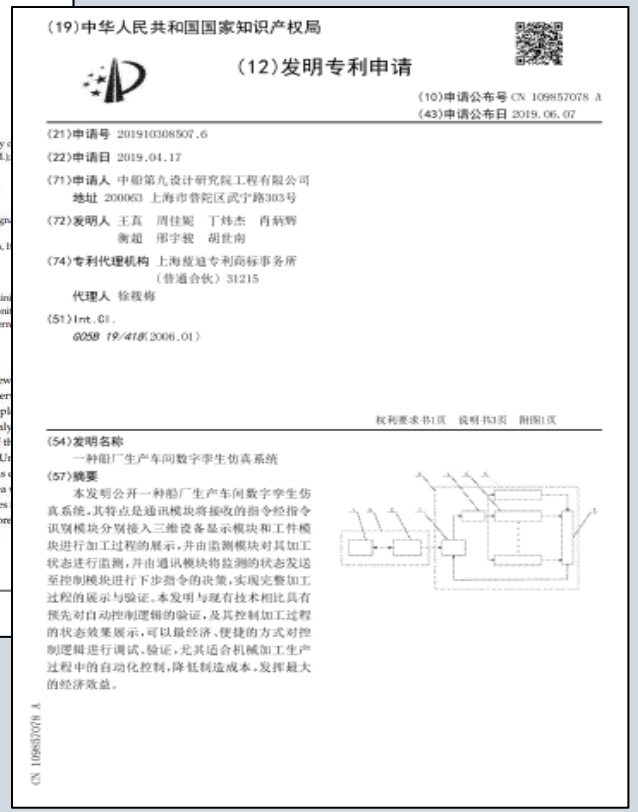
Abstract: The ability to observe the world has seen significant developments in the last few alongside the techniques and methodologies to derive accurate digital replicas of observ ronments. Underwater ecosystems present greater challenges and remain largely unexpl the need for reliable and up-to-date information motivated the birth of the Interreg Italy SUSHI DROP Project (SUstainable fiSHeries wIth DROnes data Processing). The aim of t is to map ecosystems for sustainable fishing and to achieve this goal a prototype of an U Underwater Vehicle (UUV), named Blucy, has been designed and developed. Blucy was during project missions for surveying the benthic zone in deep waters of the Adriatic Sea invasive techniques compared to the use of trawl nets. This article describes the strategies the instruments applied and the challenges to be overcome to obtain an accurately geore underwater survey with the goal of creating a marine digital twin.

Keywords: UUV; ROV; AUV; surveying; monitoring; marine; digital twin

1. Introduction



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(54)发明名称

一种船厂生产车间数字孪生仿真系统

(57)摘要

本发明公开一种船厂生产车间数字孪生仿真系统。其特点是通讯模块将接收的指令经指令识别模块分别接入三维设备显示模块和工件模块进行加工过程的展示，并由监测模块对其加工状态进行监测，并由通讯模块将监测的状态发送至控制模块进行下步指令的决策，实现完整加工过程的展示与验证。本发明与现有技术相比具有预先对自动控制逻辑的验证，及其控制加工过程的状态效果展示，可以最经济、便捷的方式对控制逻辑进行调试、验证，尤其适合机械加工生产过程中的自动化控制，降低制造成本，发挥最大的经济效益。

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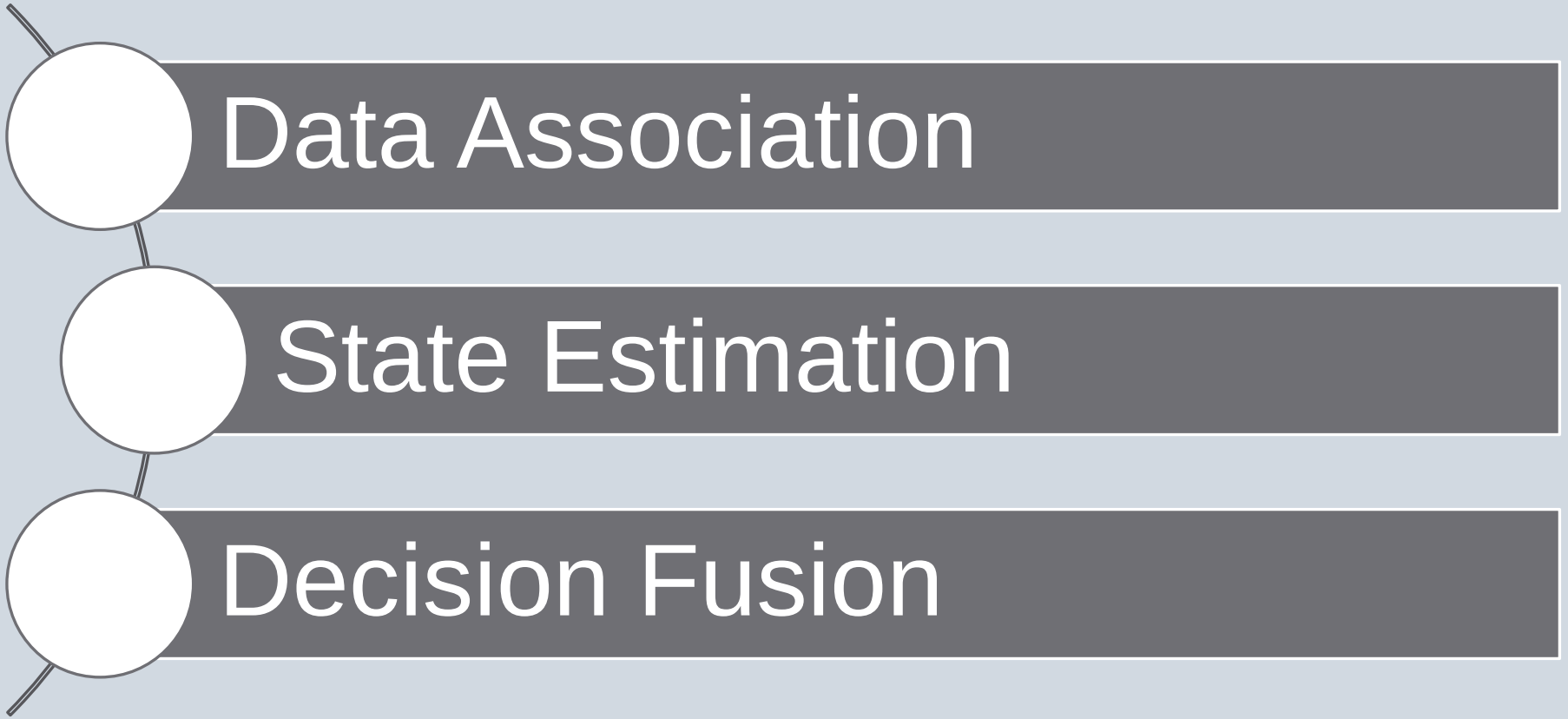
Data Fusion Techniques



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Gaps within Developed DTs

Digital twins in many defense systems lack data fusion frameworks

- Unable to support the integration of data and analytics towards an automated solution
- No room for processing of asynchronous information
- Patchwork limits functionality, resulting in DTs that have low survivability and maintainability rates

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DT Gaps to Requirements

Noted Gaps:

1. Data Framework
2. Data Management
3. System Data Integration
4. Convergence
5. Optimized Analytics

Requirements:

1. Data Framework
2. Data Management
3. System Data Integration
4. Convergence
5. Optimized Analytics

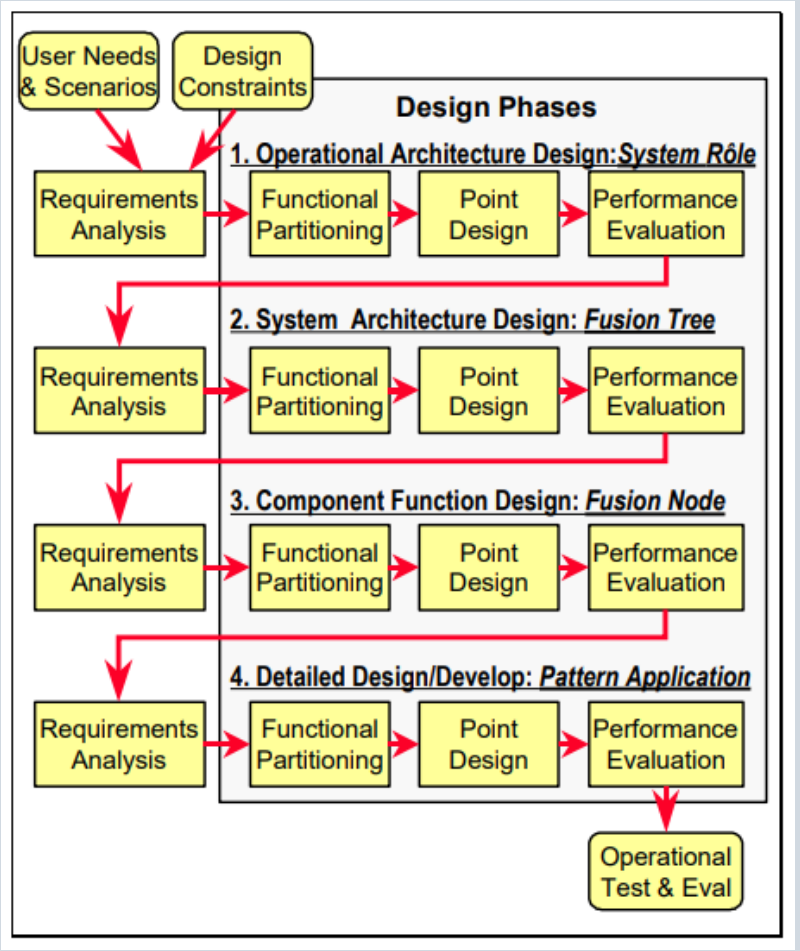
Data Lifecycle

Can use data fusion process in conjunction with data lifecycle to form the basis of requirements analysis

Requirements Analysis

Requirements analysis can be broken down at four design phases of the data fusion process:

1. **Operational Architecture Design**
2. **System Architecture Design**
3. **Component Function Design**
4. **Detailed Design and Development**



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Path Forward

1. Use open-source DT resources to perform system level product decomposition at operational architecture design level
2. Determine requirements for data fusion network system architecture design
3. Create a requirements design of data fusion nodes at the component function level, with data flow specifications among digital twin system components
4. Extend requirement analysis for detailed design elements of digital twins
5. Review existing data fusion networks within DTs to illustrate the functionality of the performed requirements analysis

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Questions?

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