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With Virtual Reality, IPN Replicates NASA-Style Astronaut Training

- **At the Houston Innovation and Development Fair, CIC researchers presented a mixed-reality and digital-twin system that even simulates a spacewalk.**
- **The model significantly reduces costs, risks, and training time; it could be implemented as a training platform for space agencies and private companies.**

Given the complexity and high cost of traditional astronaut training—which requires highly specialized infrastructure and equipment—scientists from the Instituto Politécnico Nacional (IPN) presented a mixed-reality and digital-twin prototype that replicates these training practices at NASA's "Innovation and Development Fair: Mexico at the Space Center."

Octavio Elías Piñal Ramírez, a doctoral student in Computer Science at the Centro de Investigación en Computación (CIC), and his advisor, Dr. Amadeo José Argüelles Cruz, were invited to the event held from October 13 to 15, where they showcased the virtual-reality system.

During their presentation, they explained that astronaut-training simulations require participants to interact directly with spacecraft systems, vehicles, and equipment to understand their real-world impact. For this reason, they developed immersive environments—also known as digital twins—inspired by programs of NASA and the European Space Agency (ESA).

This project reflects the IPN's commitment to advancing scientific innovation under the leadership of Director General Arturo Reyes Sandoval, aligned with the policies implemented by the administration of President Claudia Sheinbaum Pardo and the guidelines set forth by Secretary of Public Education Mario Delgado Carrillo.

The IPN researchers noted that the project could be implemented as a modular, comprehensive training platform for space agencies and private space-exploration companies. Offered through licensing or service-based models, this platform would

significantly reduce the costs, risks, and time associated with astronaut training by providing a more efficient, safer, and accessible alternative.

"Digital twins are virtual models of physical objects, processes, or systems that are continuously updated with real-time data. In this case, they are digital replicas of the physical environments where astronauts operate and where mission-specific tasks and operations are carried out," explained Piñal Ramírez.

For the project, three simulation modules were created, each featuring different scenarios and tasks based on NASA and ESA programs and systems.

"The first module is a theoretical environment that explains principles such as gravity and propulsion systems, concluding with an assessment. The second module includes two practical scenarios: an emergency simulation on the International Space Station (ISS) and a spacewalk during which participants must complete three repair tasks," he detailed.

In the third module, Piñal added, they recreated the launch of a spacecraft, incorporating characteristic sound and vibration effects. The team used a model of SpaceX's Falcon Heavy as a reference, along with digital twins of its systems.

The data obtained from the simulations were stored, analyzed, and compared with ISS records from the Jet Propulsion Laboratory (JPL) and telemetry from the Falcon Heavy launch, validating its usefulness for astronaut training, highlighted Dr. Amadeo Argüelles, a Level II member of the National System of Researchers (SNII).

For more information, visit www.ipn.mx

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