HypérTracker

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Executive summary

Energy is what moves us forward. The quest for new convenient energy sources has accompanied the human species throughout its evolution, until the great breakthrough carried by the Second Industrial Revolution, with the introduction of steam machines. However, the consumption of unrenewable sources along with questionable energy policies, soon led to critical downsides: the catastrophic effects of pollution and global warming. Since asking for a step back in energy consumption is not a realistic request, renewable sources, like solar, wind, hydroelectric and geothermic, become our only choice to save our planet. In particular, photovoltaic cells can rely on a virtually infinite source of energy emitted by the Sun. Still, low efficiencies and the huge up-front to set up a solar power plant, are a huge drawback for this technology.

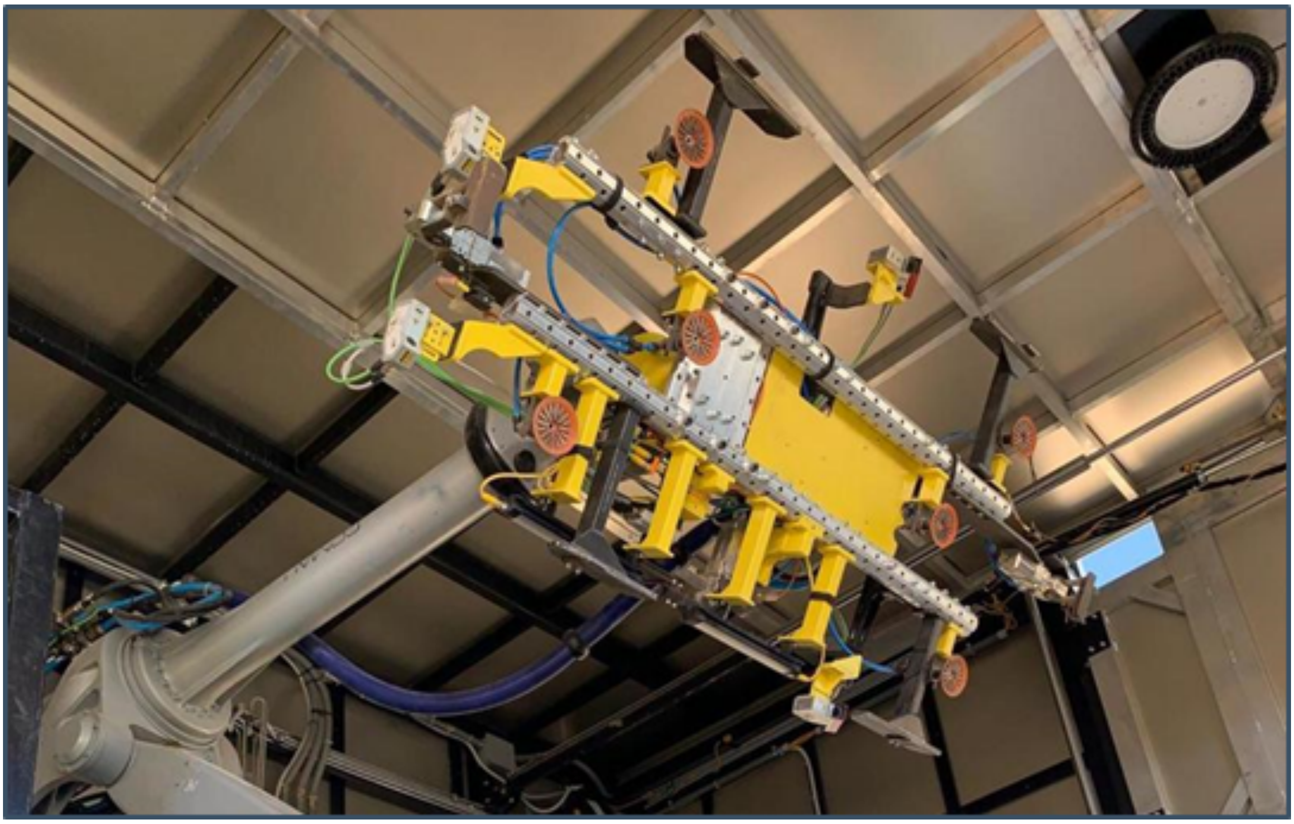
In 2018, COMAU developed Hypèrion, a robot capable of automatically installing photovoltaic modules in solar field, thanks to its robotic arm and advanced vision algorithms. Hypèrion can roam over the solar field carrying the solar modules on its back and is meant to be self-sufficient in every possible way. This would ideally remove the need for human intervention during the photovoltaic modules' installation phase, a costly, slow and dangerous procedure to be taken on by humans.

However, the robot is not self-sufficient yet, since the traditional supporting structure for the solar modules is not tailored on the capabilities of Hypérion. The traditional fastening mechanism, used to secure the panels on the crossbeams still requires man labour, along with consumables (rivets, bolts, screws, …). This severely impact the advantages that the automatization could lead to. Our goal is to develop a clamping technology for solar photovoltaic modules that would lead to no human supervision, fast installation speed and low manufacturing and logistic costs, with a success rate close to 100%.

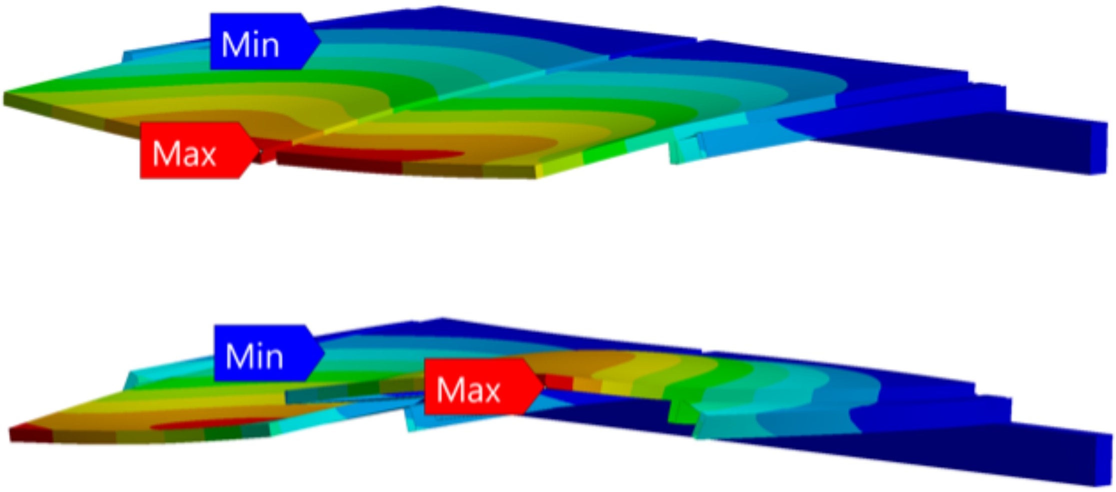
After multiple brainstorming sessions and several trackers design, realized in SOLIDWORKS and tested with a FEM analysis in ANSYS, the team was able to obtain a clean, clever design for one of the main components of the tracker, the crossbeams that support the solar modules. At the same time, we realized a user manual about foundations, to guide the sizing of the ground poles that support the whole structure, as requested by COMAU.

Key Words

#SolarTracker #SolarEnergy #PhotovoltaicModules #COMAU #Hypèrion



Hyperion robot



HyperTracker: first and second characteristic mode of the assembly

Project description written by the Principal Academic Tutor

In order to reduce the overall cost of electric power produced by photovoltaic plants, during last 2 years, Comau has exploited all its industrial automation competence, technology and experience to develop a mobile robot for automatic installation of PV modules in outdoor environment: Hypérion. The panels are mounted on a solar tracker that is constituted by a main central beam with orthogonal crossbars on top, where modules are fixed using bolts or screws. The central beam is supported by vertical pillars and its rotation is controlled by an electrical motor with an algorithm that follows sun movements. To enable robot automatic installation, bolts and screws must be replaced with quick couplers that permit modules clamping with just a simple robot movement. Actual solar trackers are remarkably optimized for manual installation, but they lack some essential features to support and enhance automatic installation:

- Quick couplers are an add-on of the structure requiring an assembly operation to mount them on crossbars instead HypérTracker must have them integrated so its design must be reinvented and the manufacturing process restructured

- Comau machine, Hypérion, features some of the most advanced vision systems to guide the robot in the desired position for installation over the solar tracker, but HypérTracker is supposed to improve vision systems performance including repeatable easily recognizable frames

- HypérTracker structure must have a stable geometry and dimensions tolerances compatible with automatic process

The objective of the project is to conceive, design and realize a new solar tracker that integrates those requirements, using a comprehensive approach that takes into account also manufacturing, construction and logistics aspects of this complex challenge.

Team description by skill

The project requires different competences ranging from functional and structural mechanics, construction and logistics to automation and programming to manufacturing and production. In order to achieve every single objective it is necessary that those competences are mixed and integrated.

The HypérTracker teams has the right competences the accomplish the objectives stated in advance for the project. The highly vertical skill in structural mechanics due to the presence of one Mechanic Engineer together with three Space Engineers has allowed the team to develop a complex structure and successively to validate it using Finite Element Analysis techniques.

The final goal of the project was to provide an end-to-end solution with a high innovative content, to comply with it each team member has exploit his own expertise cover every aspect of the tracker's design process, from logistics to foundations and associated civil works.

The team has been assembled in the best way possible, each team member has had the possibility to challenge itself on topics related to its correspondent field of study as well as to adopt a comprehensive approach to the overall problem.

Goal

Our project focuses on the development of a new solar tracker design, tailored to Hypérion abilities in automatic installation of photovoltaic modules. Building a solar plant requires a lot of resources that need to be properly packed, handled, transported, unpacked and assembled. The purpose of the HypérTracker project is to come up with a solution that streamlines such operations, making them time and cost effective. The main objectives identified are the following:

• Design of a beam geometry that can easily accommodate the photovoltaic module, locking all possible degrees of freedom. The ideal clamping systems is integrated in the crossbar itself, removing the additional phases of add-ons installation currently found in the preparation of the structure for Hypérion. Still the design should ensure the assembly process to be completed in the shortest time possible and consisting of only a few simple movements of the robotic arm. The final configuration will grant the structural integrity of the whole assembly under all relevant load, both aerodynamic and vibrational.

• Optimization of the photovoltaic field building process in terms of logistics, operators management and materials handling: the main goal is the selection of the optimal and less expensive manufacturing process to produce the beams, and the overall organization of the solar field

• Development of a user manual about foundations, presenting a static analysis of the structure, a determination procedure for wind loads, an in-depth evaluation of the type of soil influence, a focus on the main solutions available in the market and the final considerations for a proper sizing of the ground poles

• Evaluation of the most suitable power storage solution

• Analysis of the aeroelastic behaviour of the panel array and selection of the optimal damping systems

• Manufacturing of a final prototype and on-field testing with Hypérion.

Understanding the problem

Current clamping solutions for solar panels are not optimized for Hypérion robot, as they require workers' intervention to deal with bolts and screws.

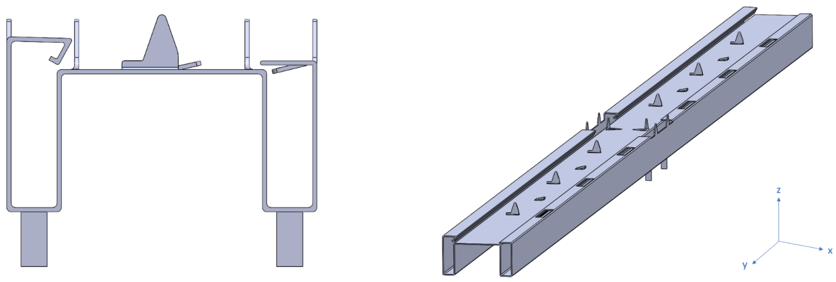
Many studies demonstrate that considering the amount of workforce required for each phase of a large solar field project the Operation and Maintenance (O&M) phase has been identified as the one requiring the highest amount of workforce and, at the same time, the one with largest room for further improvement. The whole package of on-site activities is deeply time and resource-consuming, especially for large-scale projects, therefore the need for automation in this sector is particularly urgent to furtherly drive the overall cost of the PV technology down.

Exploring the opportunities

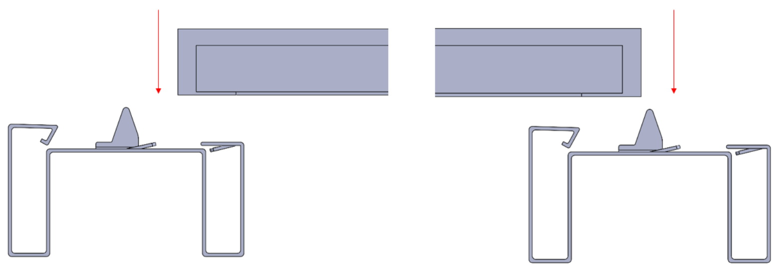
Hypérion and the HypérTracker project would allow to bring disruptive innovation in the renewable energy field, through the introduction of automatization in the installation process of photovoltaic modules. This could push COMAU penetration in the renewable energy market, thanks to a new, safer and more efficient way to set up large solar farms. The solution would also represent one of the first outdoor robot-integrated systems in the world, with a solar tracker designed and manufactured in order to optimize the robot operations.

Generating a solution

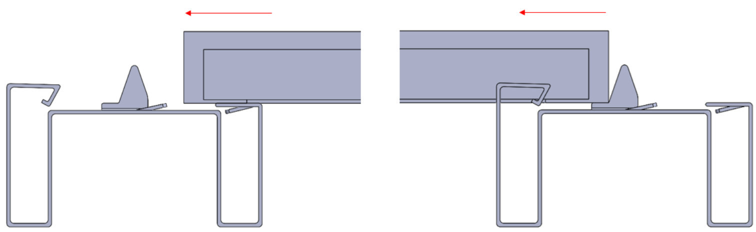
The first attainment of the project is the shape of the beam, designed to allow sheet metal folding as primary manufacturing technique. The only additional manufacturing procedures needed would be punching, for the pins and the elastic tabs, and a cut in the middle of the beam to allow the insertion of the panels



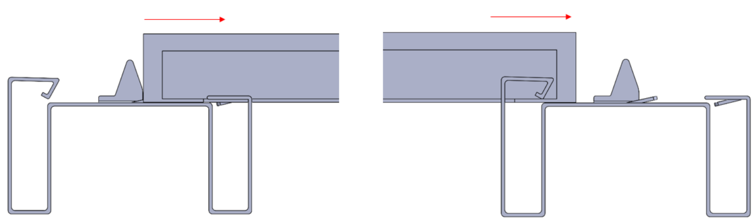
This configuration requires three movements of the robot to lock the panel in position. First, the panel is placed vertically on the beam with the guide of the vertical pins.



Second, the robot moves the panel towards the left, until the panel frame reaches the central part of the beam.



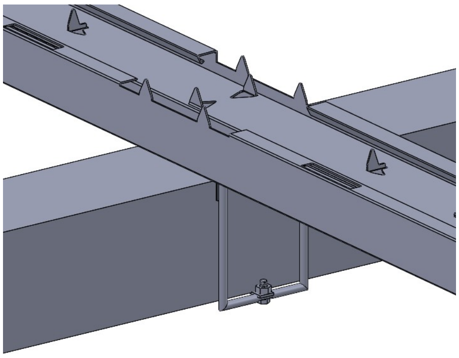
Finally, the panel is moved to the right until the elastic tabs spring back to their initial shape, reaching the final position.

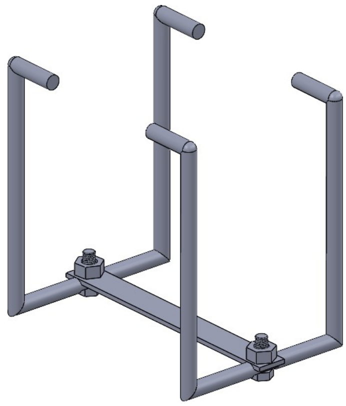


The panel does not need to be inclined during the installation process. This represents a huge achievement, as smaller angle errors are magnified due to the large dimensions of the photovoltaic modules.

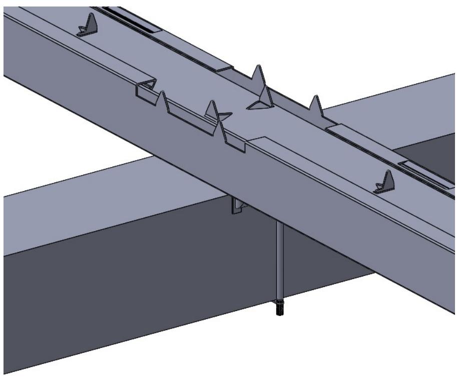
Moreover the team focuses on the design of the connection system between the crossbars and the central beam. Two different configurations have been thought based on the same concept.

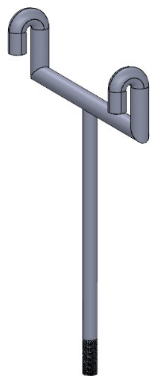
The first configuration envisioned a simple double-bended steel tube with a flattened and drilled point to allow the insertion of a pair of screw and bolts. The advantage of this solution is the reduced number of consumables needed and the ease of manufacturing. Indeed, only bending and flattening is required, allowing an extremely fast manufacturing process.





The second configuration has been designed with a threaded end, in order to eliminate the need of additional screws, and could be secured directly with a locking plate and a couple of bolts. The main concern with such configuration is the manufacturing process. Instead, it probably required the soldering of two parts, resulting into additional costs.





The fundamental concept for both configurations was appreciated due to the extremely reduced need of consumables, comparable to what is currently employed for non- automation-friendly solution.

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