Toward active thermomechanical control in precision mechatronics

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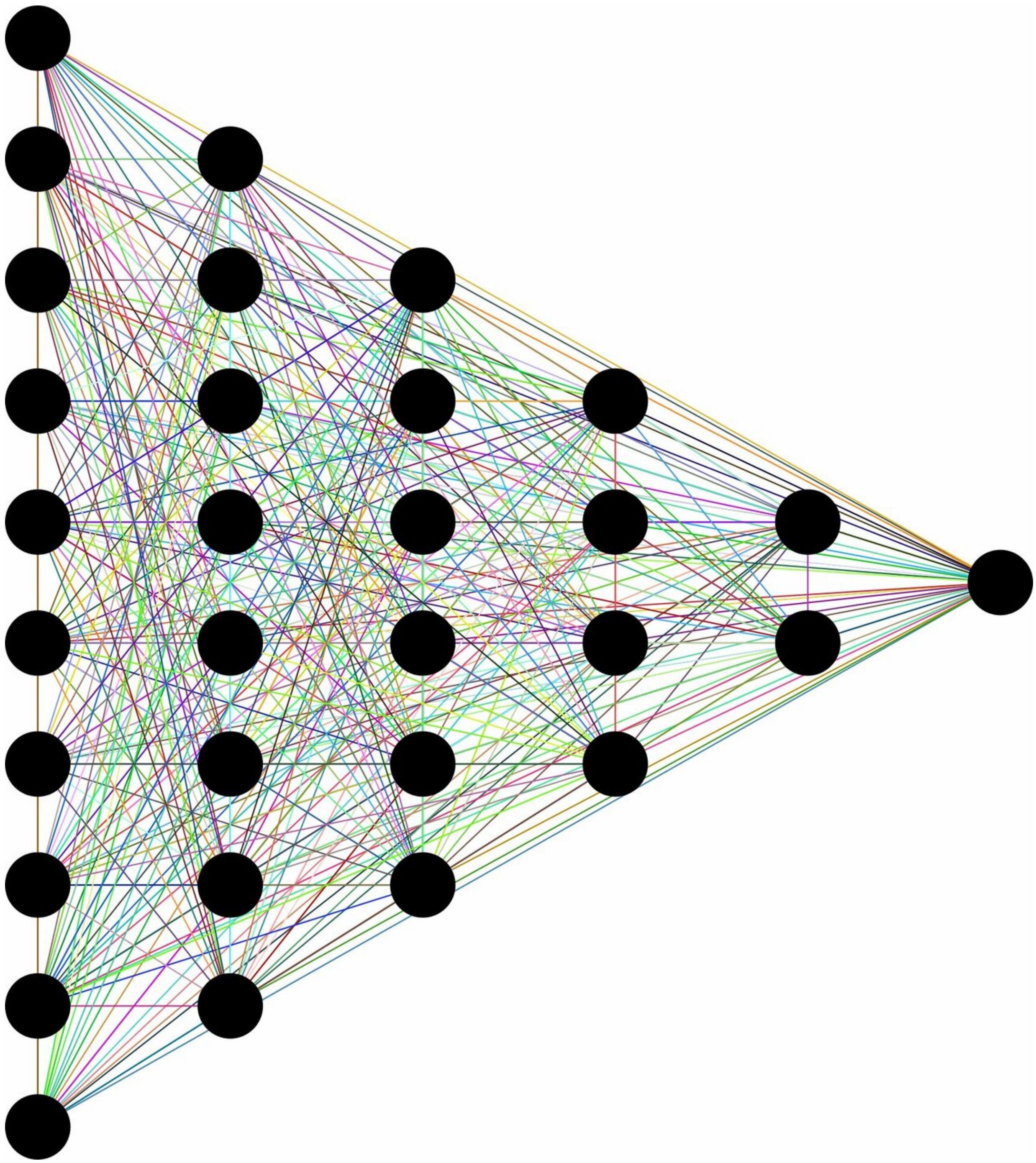

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Next-generation mechatronic systems form a vital part of the infrastructure that facilitates the technological advancements and innovations in the high-tech manufacturing, life sciences and medical industries. These systems have high requirements for accuracy and throughput, which means a passive isolation approach to thermally induced deformations is no longer enough. Ph.D. candidate Enzo Evers of the TU/e department for Mechanical Engineering pursued the idea of an active thermomechanical control approach by providing contributions in the areas of modeling, actuation and control. He defended his Ph.D. thesis on 7 January.

Keeping up with the increased demands on mechatronic systems requires advanced control methods and complex designs, based on the concept of systems-of-systems. Over the years, there has been impressive progress in advanced motion control of precision mechatronics. Today's motion systems are capable of positioning up to the nanometer scale. As a result of these advancements, any positioning errors can be compensated almost completely. That means that thermally induced deformations are now no longer negligible: they are a more pronounced detriment to overall system performance and must be taken into account.

Rather than relying on a passive isolation approach, researchers such as Evers are now looking into an active approach to thermally induced deformations. The active approach includes predicting and controlling thermally induced deformations through accurate modeling and control. This allows a level of overall system performance beyond that of the classical mitigation-based approach that relies on mitigating deformations through mechanical design and passive isolation from the environment.

Using transient data

In his Ph.D. research, Evers contributed a comprehensive modeling approach to thermomechanical systems that significantly reduces the time needed to identify a system. This modeling approach uses transient data that existing approaches would otherwise discard. Evers also developed a complete framework for modeling and control of Peltier elements. These thermoelectric elements can both heat and cool, enabling bidirectional temperature control at performance-critical locations in the systems. Finally, Evers created a systematic approach for appropriate coupling of a set of subsystems. This improves their combined performance and allows for leveraging the mechanical control system to compensate for thermally induced deformations.

The contributions of this thesis form a comprehensive set of tools and techniques for industrial practitioners to move towards an active thermomechanical control approach in precision mechatronics. The techniques have already been successfully applied to several experimental industrial applications, in collaboration with partners within the Advanced Thermal Control Consortium.

More information: Identification and active thermomechanical control in precision mechatronics. research.tue.nl/en/publication … ntrol-in-precision-m Identification and

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