Concept of Twins

The concept of using "twins" is rather old. It dates back to NASA's Apollo program, where at least two identical space vehicles were built to allow mirroring the conditions of the space vehicle during the mission. One vehicle remaining on earth was called the twin. The twin was used extensively for training during flight preparation.

In this sense, every kind of prototype, which is used to mirror the real operating conditions for simulation of the real time behaviour, can be seen as a twin. Another form of a "hardware" twin is the "Iron Bird". An **iron bird** is a ground-based test rig used for prototyping and integrating aircraft systems during the development of new aircraft designs. Iron birds are used for system integration, reliability testing, and shakedown testing of aircraft systems such as landing gear, avionics, hydraulics, and flight controls.

What is Digital Twin?

A digital twin is a digital replica of a living or non-living physical entity. Digital twin refers to a digital replica of potential and actual physical assets (physical twin), processes, people, places, systems and devices that can be used for various purposes.

Why Digital Twin?

Any entity for which we need to create a twin, itself consists of components which themselves are complex in nature. So it is complex System of System. It has to achieve certain goals while operating in dynamic and uncertain environment. Even these goals may also change over time. To achieve this, current practice adopts a variety of approaches based purely on mathematics and/or past data and/or human expertise Given the high degree of complexity and ever-increasing dynamics, current practice is turning out to be ineffective.

Hence**, Digital Twins are emerging as a promising line of attack** through confluence of fields such as Modelling & simulation, Artificial Intelligence, Control Theory, Knowledge Engineering, and Software Engineering.

Digital Twin market, today estimated at 12 Billion US$, is expected to grow to 110 Billion US$ by 2029 making it one of the hottest fields

What this course aims at?

We begin by providing a rationale for the need of digital twin technology by highlighting lacunae in current practice. We also state advantages accruable from digital twins. We present a *tour de force* on utility of digital twins in cyber-cyber, cyber-physical, and societal systems while also touching upon biological systems.

We get into the details of digital twin technology starting from a conceptual view to a variety of implementation mechanisms while touching upon their unique characteristics. We then present digital twin life cycle, key concerns for each of the phases, and the necessary technology for addressing these concerns. We highlight the need of a method for effective and efficient digital twin life cycle, and the necessary automation support. We also explain how Gen AI is being leveraged here.

We illustrate the benefits accruable from digital twins through three real-world industry-strength use cases (examples)– one each from cyber-cyber, cyber-physical and societal spaces. We also touch upon some unique applications of digital twins that are underway.

We conclude with an evaluation of digital twin technology and highlight ongoing research aimed at addressing key future challenges.

At end of this multi-disciplinary course, you would have learnt *what are digital twins*, *why are they required, how can they be realized, what benefits do they bring along,* and *how best to use digital twins to address a variety of real world problems*. You will also get more-than-cursory introduction to the exciting world of modelling & simulation, actor based modelling, system dynamics, machine learning, Generative AI, control theory, and model driven engineering.

Prior introduction to programming (preferably object oriented programming) is helpful but not a showstopper.

See you there.
TCS Research (TRDDC)

Timings & Mode of evaluation: Please note that the course will be taught on Fridays/Saturdays as TCS resource persons would be teaching this course by physically coming over the campus.
Assignments/ Small projects would be given to students to make them understand the subject better.