Trends in Mechatronic Engineering and Education

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The pace of innovation is increasing dramatically owing to developments in

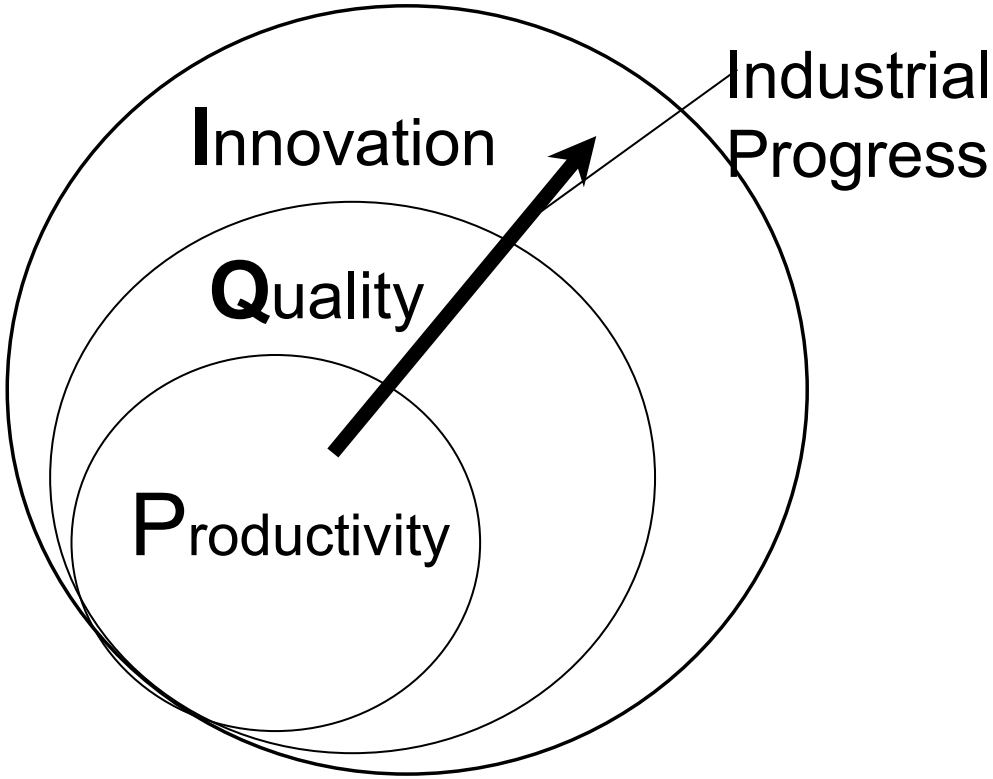
- Communications
- Computerization,
- The Internet, etc.,
- Globalization of markets
- Global distribution of the processes of new product realization (concept development, design, prototyping, manufacture, and servicing).

Innovation can become the force that could

"liberate humanity in general from the preventable evil called poverty [von Braun '97]."

We cannot ignore the onward march of technological innovation.

P→Q→I Competitive Strategies



- **Productivity**
  = Functional output/Input:
  → Satisfy customer needs

- **Quality**
  → Satisfy customer wants

- **Innovation** → Excite the customer through new ways of delivering value.

Value = Worth /Cost

Productivity

Reduce denominator through process innovations and using the *corporate left brain.*

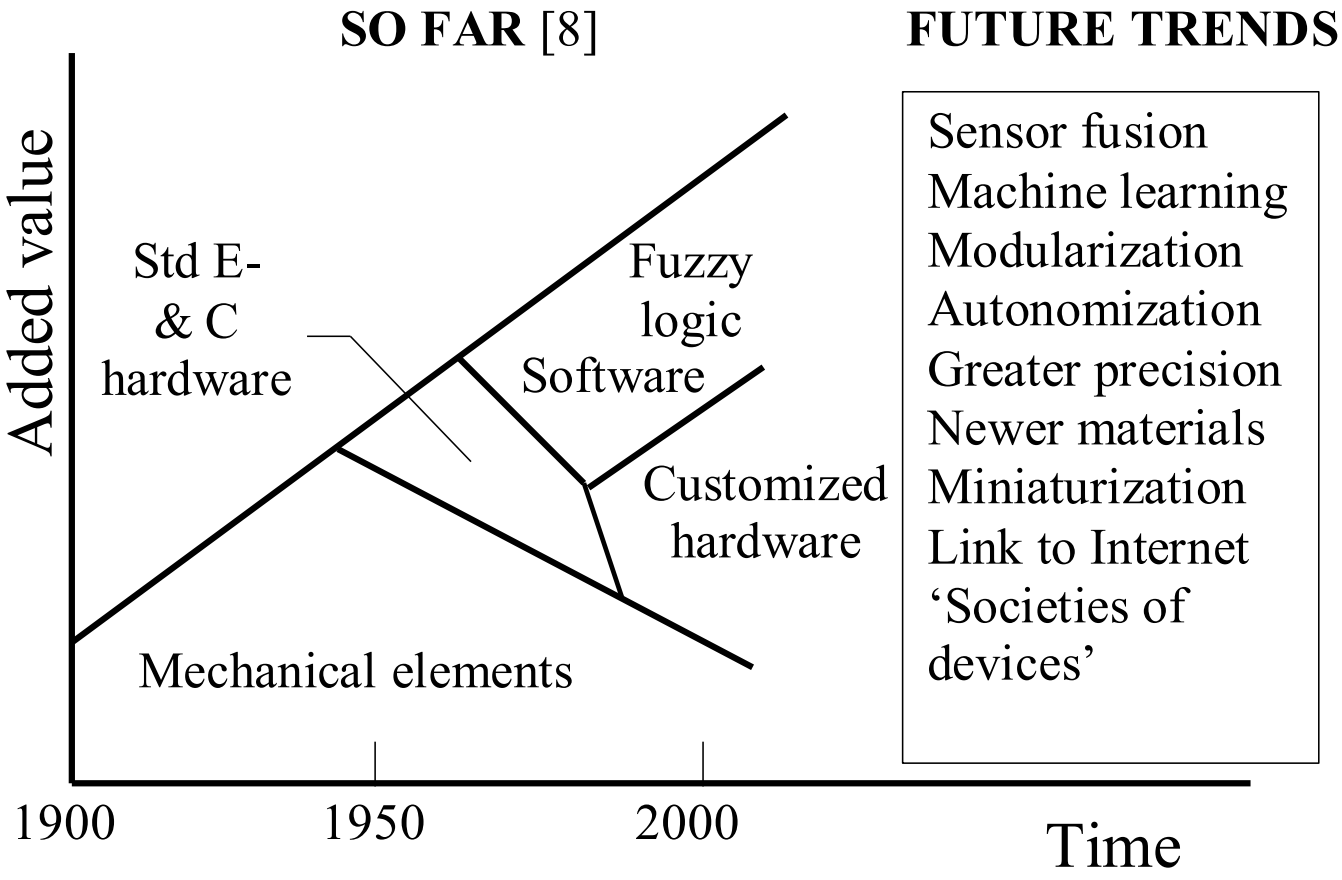
Quality

Increase numerator through process innovations using the *corporate heart.*

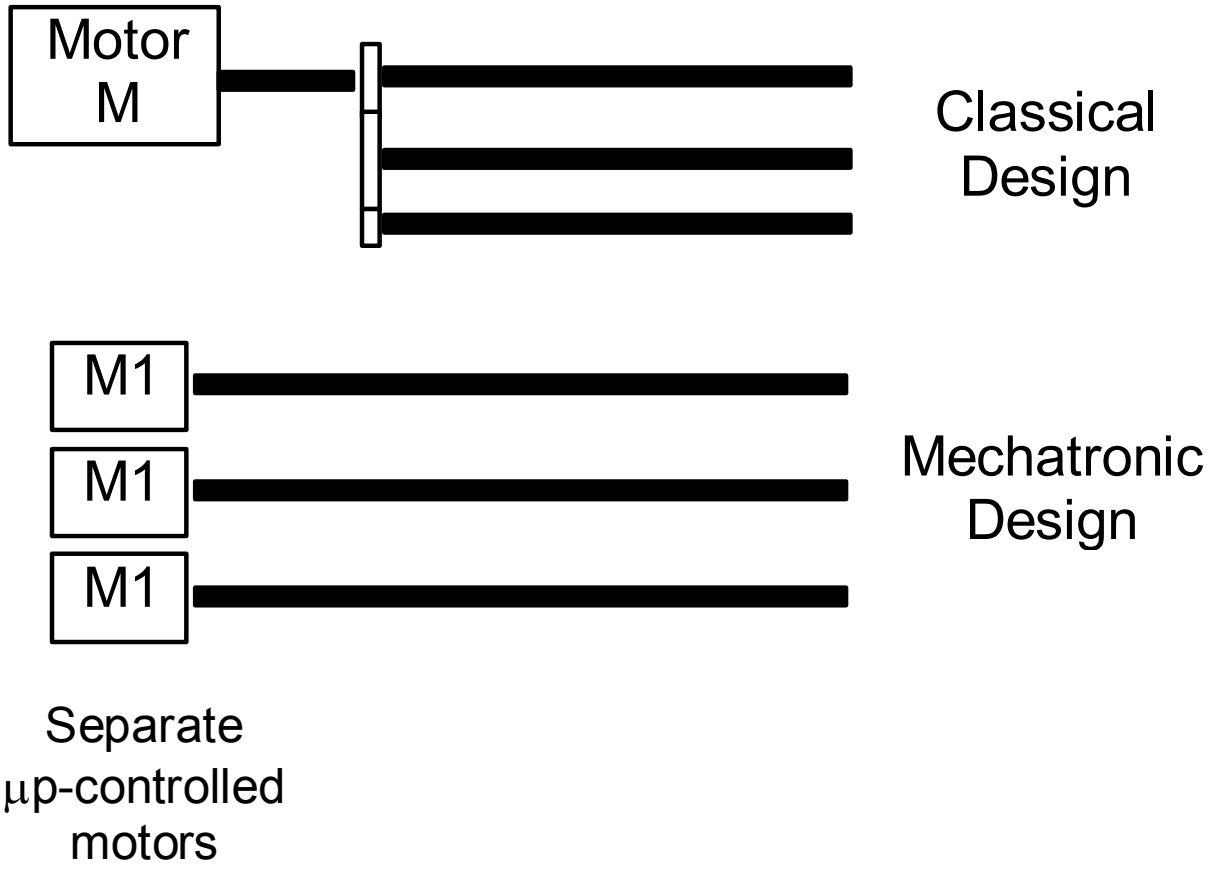
Innovation

Increase numerator through product innovations and using the *corporate right brain.*

Trends in mechatronic engineering



Classical and mechatronic speed control



Some types of mechatronic products

TYPE	EXAMPLES
• Transducers and measuring instrumentation	• Ultrasonic receiver, Electronic scale
• Processing machines	• Turning and machining centers, Bonding machines,Robots
• Industrial handlers	• Robots, Component insertion machines
• Drive mechanisms	• CD players, Printers, Disk drives
• Interface devices	• Keyboards

Benefits of mechatronic engineering

BENEFIT	EXAMPLES
• Faster response time	• Servo-motion controller, Camera
• Better wear and tear characteristics	• Electronic ignition
• Miniaturization potential	• Camcorder
• Easier maintenance and spare part replacement	• Washing machine

BENEFIT	EXAMPLES
• Memory and intelligence capabilities	• Programmable sequence controllers
• Shortened set up time	• CNC machines
• Data processing and automation	• CNC machines
• User friendliness	• Photocopier
• Enhanced accuracy	• Electronic calipers

Embedded computers

↓

New Process & product functionalities

Fuzzy Logic

+

ANN

++

↓

Smart Products

Emergence of Mechatronics

- Japan first recognized the strategic importance of mechatronics as a distinct discipline.
- In 1990, a full PhD project was in Denmark to mechatronic design.
- Australia, Hong Kong, Mainland China, and UK have MTE courses and programs.
- In Singapore, mechatronics is even introduced at the secondary school level.
- In Russia, mechatronics courses are introduced within aeronautic engineering programs.

The proliferation of mechatronic engineering programs in universities worldwide is leading to a deeper understanding of

- the specific nature of mechatronic engineering
- how it could be taught more effectively
- the software tools needed for mechatronic design and its teaching

What is Mechatronic Engineering?

Mechatronics is "*a synergistic combination of precision mechanical engineering, electronic* [read computer] *control and systems thinking in the design of products and manufacturing processes* [Dinsdale 1989]

What it is NOT mechatronic engineering?

- Mechatronics is
- "*the application of microelectronics in mechanical engineering* (MITI, Japan)"
- "*a combination of mechanical engineering, electronic control and systems engineering in the design of products and processes*."

What mechatronic engineering IS and what it IS NOT

$M + E + C \neq$ Mechatronics

$M \cup E \cup C \neq$ Mechatronics

$M \cap E \cap C \neq$ Mechatronics

What Mechatronics IS NOT

$\overrightarrow{S(M,E,C)} \Rightarrow$ Mechanical Goal

What Mechatronics IS

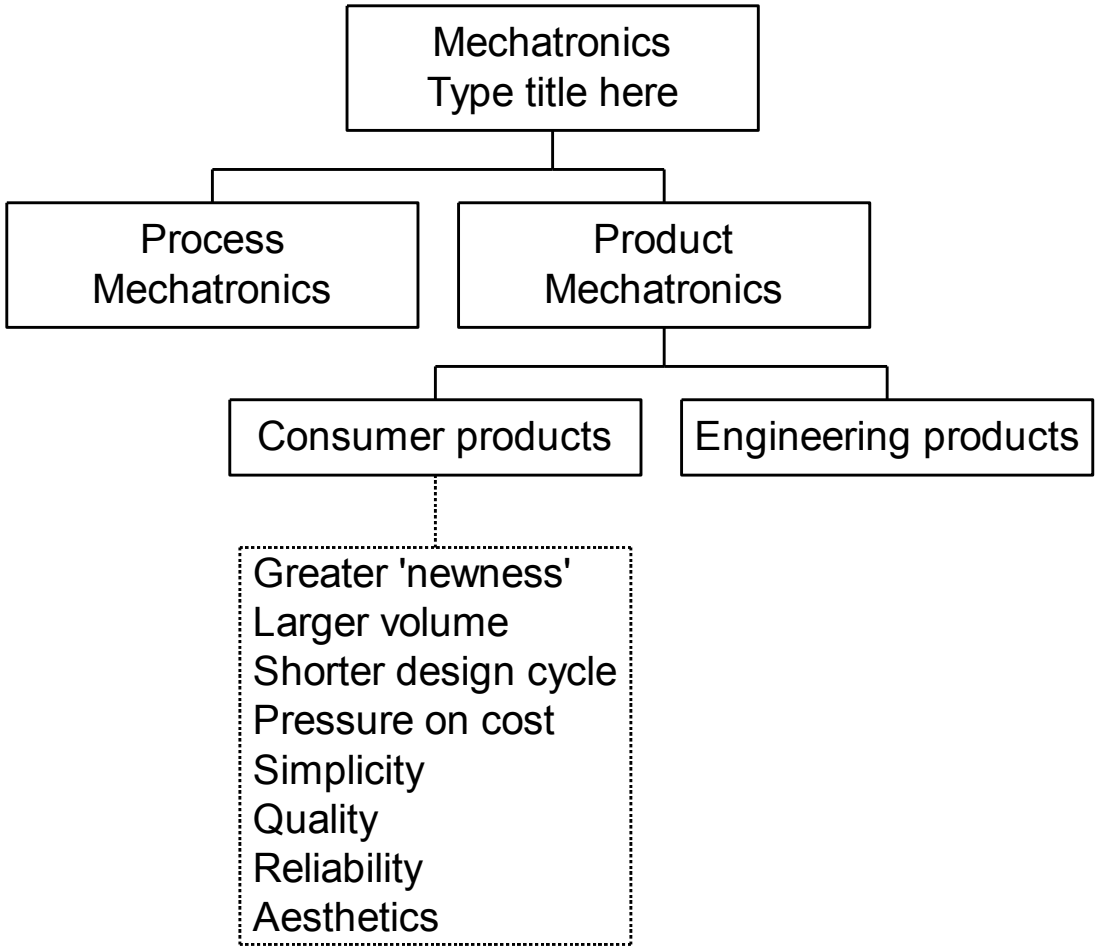
Essential features of mechatronics

- There must always be a design goal that is mechanical in nature.
- The design solution is invariably a system.
- The aim of mechatronics is to produce a competitive solution NOT any solution.
- Mechatronic design invariably involves tradeoffs between the advantages of alternative M, E, and C solutions ($M \rightarrow E \rightarrow C$)

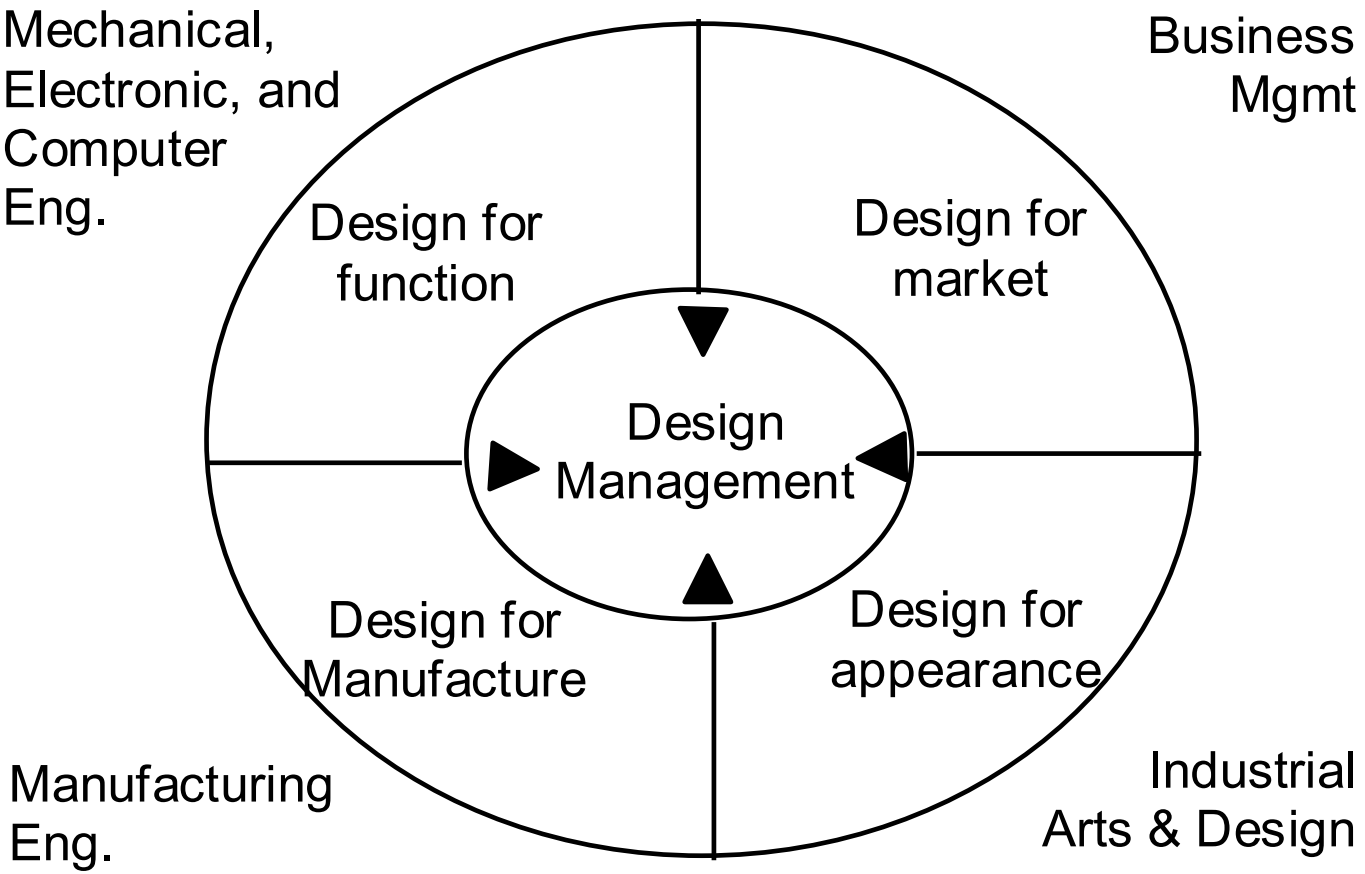
What professional roles do Mechatronic engineers fulfill?

What knowledge and skills do they need?

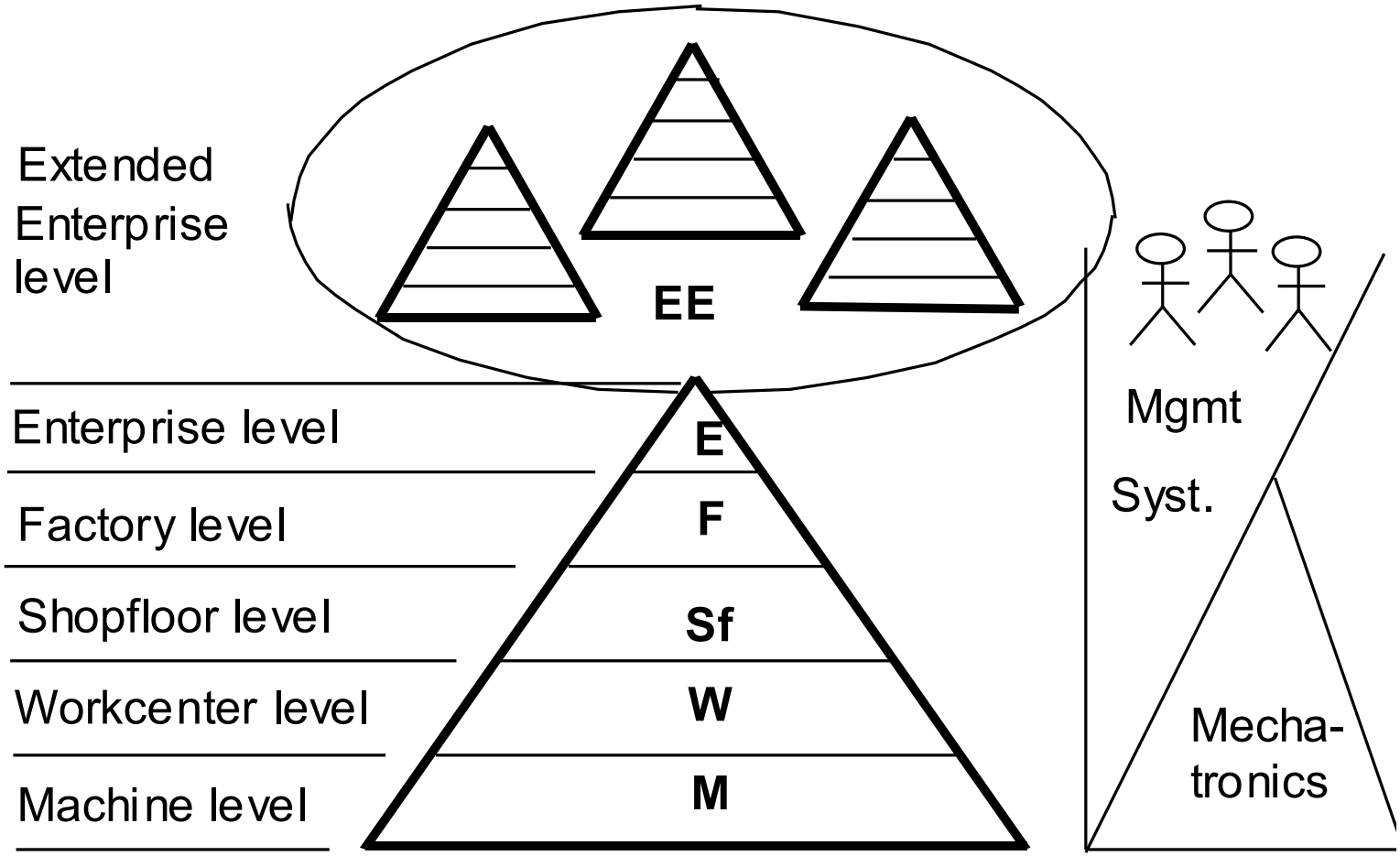
The scope of mechatronic engineering



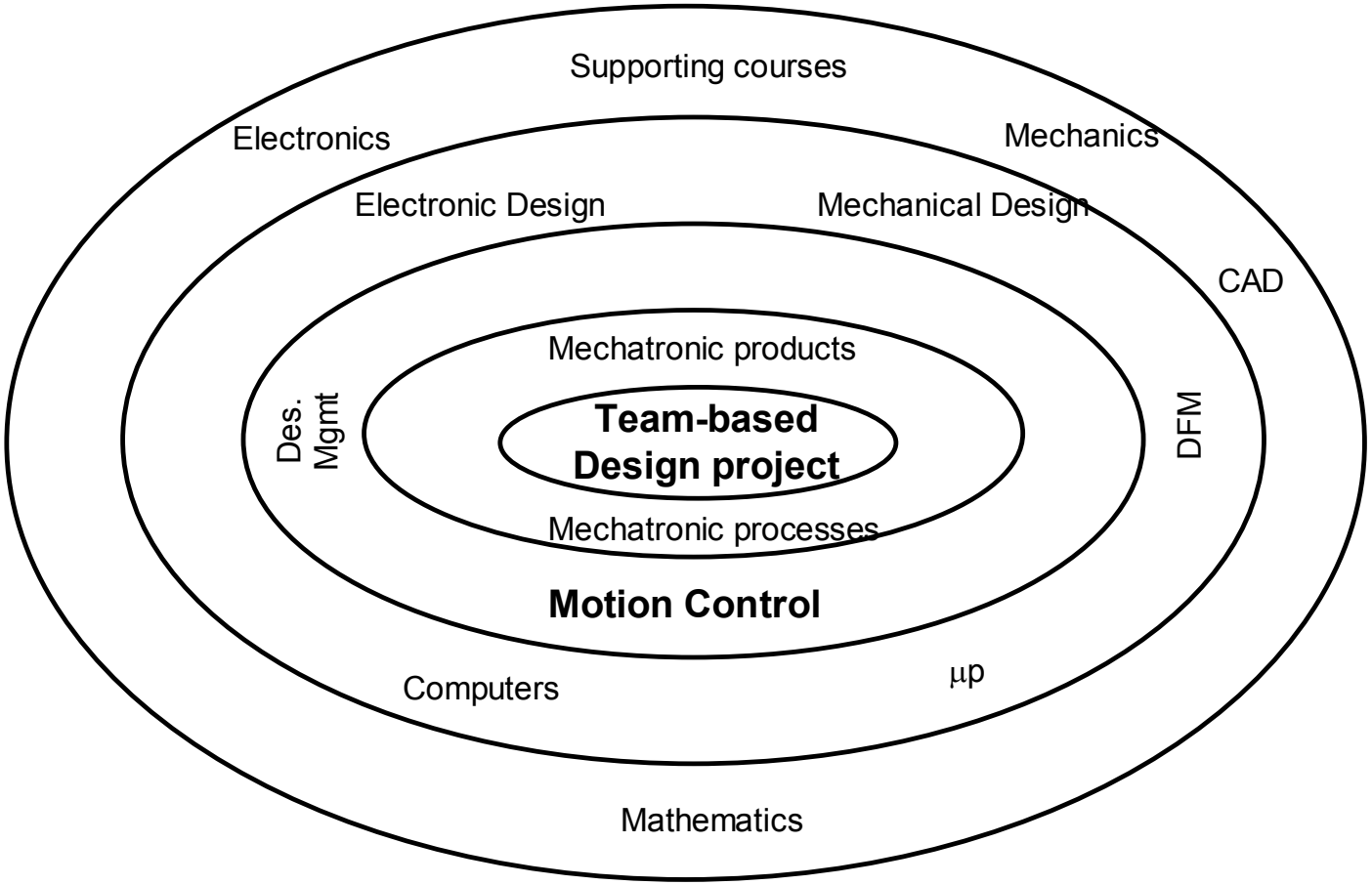
The Role of Design Management



Contemporary industrial structure



BEng. Mechatronic Eng. at City U of Hong Kong (2000)



Team-based projects can be used to achieve

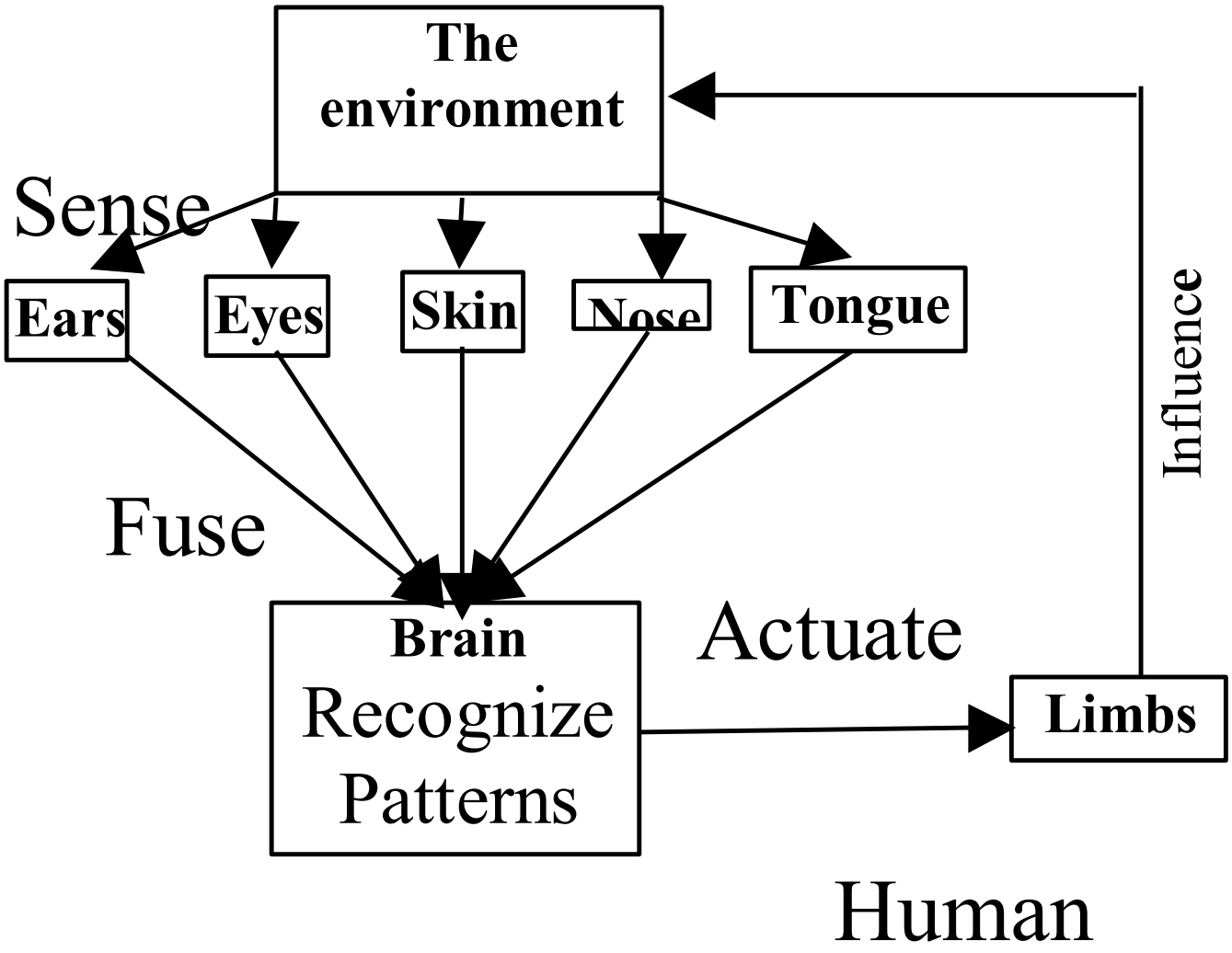
- experience-based learning of group goals,
- individual accountability,
- equal opportunities for success,
- team competition,
- task specialization
- adaptation to individual needs

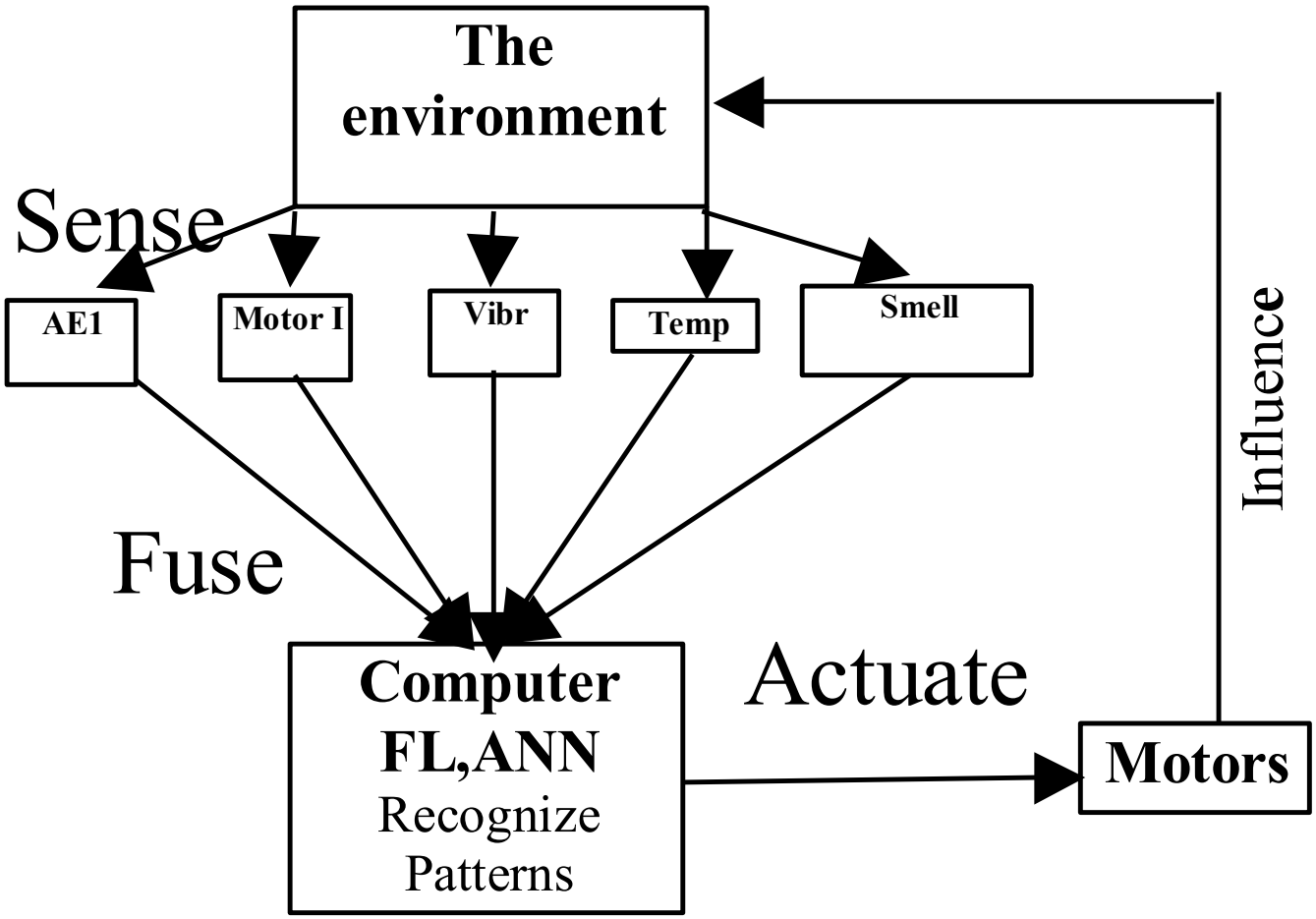
Some Design Projects undertaken by grous Of BEng Mechatronic Eng. At City U of HK

- Smart vaccuming robot
- 4-axis CNC Turn-Mill Center
- Programmabale Home Kitchen System
- High Rise Building Window Cleaning Robot
- Intelligent Wheelchair
- Smart Radio Frequency System for Supermarket Checkout.

Future trends in mechatronic engineering

- Sensor fusion
- Machine learning
- Autonomization
- Modularization
- Greater precision
- Newer materials
- Miniaturization
- Link to Internet
- ‘Societies of devices’


The environment
Sense
Ears
Eyes
Skin
Nose
Tongue
Influence
Fuse
Brain
Recognize Patterns
Actuate
Limbs
Human



Mechatronics

Machine learning:

- Intelligence means adapting to the environment and improving performance over time.
- Learning can be reflexive or reflective.
- ANN and fuzzy logic are tools for learning patterns.

Autonomization

- The development of the ability to survive and perform robustly while the external environment changes.
- Mechatronic devices will be able to reset their local goals autonomously under changing external environments so as to meet the broad system-level goals set by human beings.

Modularization

- Will be a consequence of autonomization.
- Mechatronic sub-units will encapsulate all the abilities required for local goal setting, control, and learning.
- The sub-units will be self-contained and intelligent.
- These will appear as black boxes that just need to be selected and interfaced for a specific application.

Miniaturization

Trend towards mechatronic units of significantly smaller size.

- Precision engineering
- newer materials (composites, diamond coatings, etc.)
- Nano-technologies

Links to the Internet:

- Mechatronic units will be connected via the Internet to the rest of the world.
- Will be able to access the information and knowledge base available on the Internet so as to optimize its own performance.
- Will be able to communicate its operational status to remote monitors.

(e.g., For instance, one would be able to query from one's office the refrigerator at home about its contents)

Societies of devices:

• Minsky: "[M]ind is made up of many smaller processes. These we'll call *agents*. Each mental agent by itself can only do simple things that need no mind or thought at all. Yet when we join these agents and societies—in certain special ways—this leads to true intelligence."

• Via the Internet, mechatronic devices will join 'societies' of devices with a common purpose or interest.

Societies where mechatronic engineering educators can keep up will see quicker economic progress.

What could we in Andhra Pradesh do?