Concepts of Designing and Implementation of Systems

Dr. KRISHNA RAJ
Professor and Head,
Dept. of Electronics Engineering
&
Dean of Incubation Hub
H.B.T.U. Kanpur
Kraj_biet@yahoo.com

System? **DEFINITION**

- A collection of parts that work together to achieve a goal/task
- A set of objects and relationships among the objects viewed as a whole and designed to achieve a purpose

INPUT → **PROCESS** → **OUTPUT**

FEEDBACK

Effective Methodology ? :System

Effectiveness =f (Human skills, software, hardware)

Developing an Efficient Algorithm

Practical Approaches

LT/ZT FT DTFT

DFT FFT

STFT

CWT/DWT

Basis functions vary in frequency (called "scale") as well as spatial extend:High frequency basis covers a smaller area

:Low frequency basis covers a larger area

Specifications

(Determination of parameters)

DECISION

Static (Polynomial(s))

Dynamic

Decision of System

Analog (differential)

Digital (difference)

QUANTIZATION AND ANALYSIS

Implementation

Code for Algorithm} Program :

Mixed C & Assembly for TMS320c6713]

IDE

Loading the program to processor

DERIVATION(Realization)

$$y(i,j) = -\sum_{k=1}^{n-1} b_k \frac{d^k y}{dt^k} + \sum_{k=0}^{m-1} b_k \frac{d^k y}{dt^k}$$

$$y(i,j) = -\sum_m \sum_n b_{m,n} y(i-m, j-n) + \sum_m \sum_n a_{m,n} x(i-m, j-n)$$

$$\left[y(n) = -\sum_{k=1}^{N} b_k y(n-k) + \sum_{k=0}^{M} a_k x(n-k) \right]$$

Coefficients (a_k's, b_k's)

LTI (Deterministic)

Adaptive (stochastic)

- Response type (LP,HP,BP,BS)

Matlab

Design Methods

MA(FIR)

AR(IIR)

APPOXIMATION (Design Criteria)

(Approximation)	Methods (Approximation)
FIR(Equiripple, Least-squares, window, Constr. Least-squares, Complex Equiripple, Maximally Flat, Least Pth-norm, constrained Eaquiripple, Generalized Equiripple, Constr. Band Equiripple, Interpolated FIR)	Analog→Digital •Butterworth •Chebyshev I •Chebyshev II •Elliptic •Maximally Flat •Least Pth-norm •Constr. Least Pth-norm

Algorithm for the computation of coeffs & Enhancement of the Designed Algorithm

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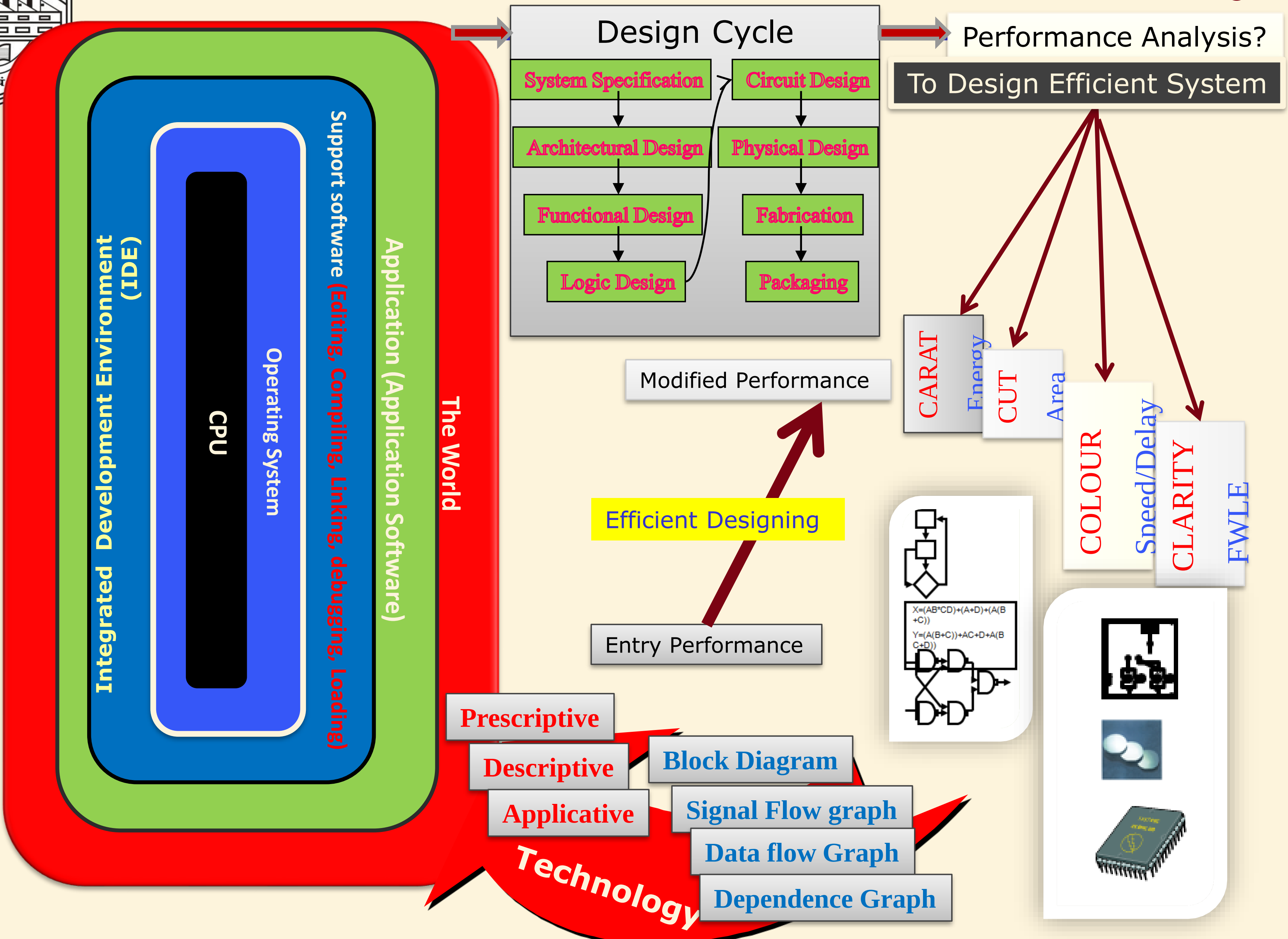

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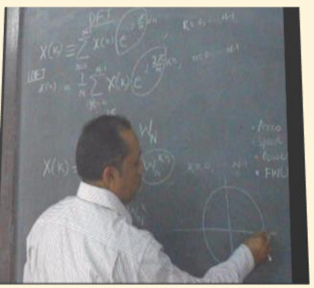
Definition ⟶ Mathematical Equation(s) ⟶ TF ⟶ PZ

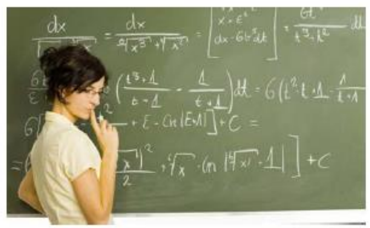
Characteristics : Time domain ⟶ Impulse response, Step response

: Frequency domain ⟶ Amplitude response, Frequency response

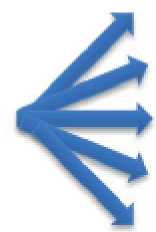
Structure : BDG, SFG, DFG, DG

Design (computation of coefficients)





Researchers, scientists, developers



Engineers that build things

Our objective: Developing an Efficient DSP Algorithm : DFG

- Critical path **the path with the longest computation time among all paths that contain zero delays**
- Pipelining **increases the clock speed or sample speed**
- Parallel Processing **Converts a (SISO) system to (MIMO) system via parallelism**
- Retiming **used to change the locations of delay elements i.e. to increase the clock rate of a circuit by reducing the computation time of the critical path.**
- Folding **to create a new program describing more than one iteration of the original program.**
- Unfolding **Used to reduce the number of hardware functional units (FUs) by a factor of N at the expense of increasing computation time by a factor of N**

Creating FIR Filters

Theoretical Concepts | Mathematical Model / Functional Description | Architectural Design

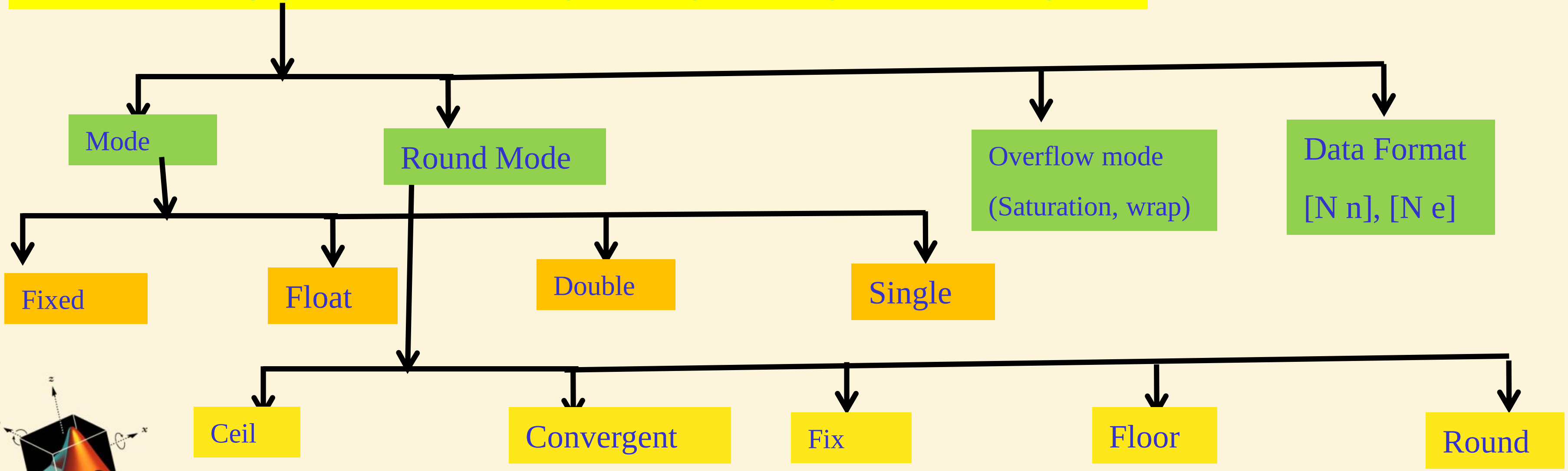
Matlab

2. Decide on a realization structure
3. Decide how coefficients will be quantized.
4. Compute quantized coefficients

CCS

5. Decide how everything else will be quantized (input samples, output samples, result of multiplies, result of additions)
6. Write code to realize filter
7. Test filter and compare to theoretical expectations

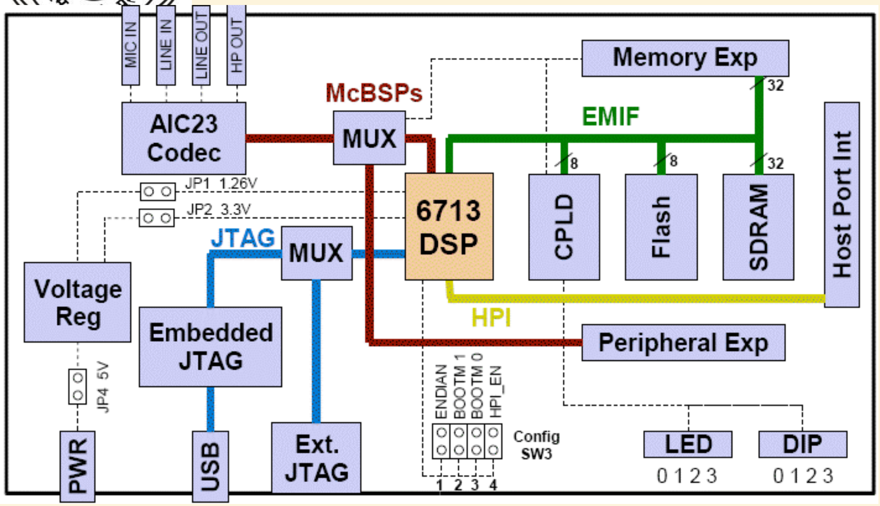
Quantization (i/p, coefficients, o/p, multiplicand, product, sum)



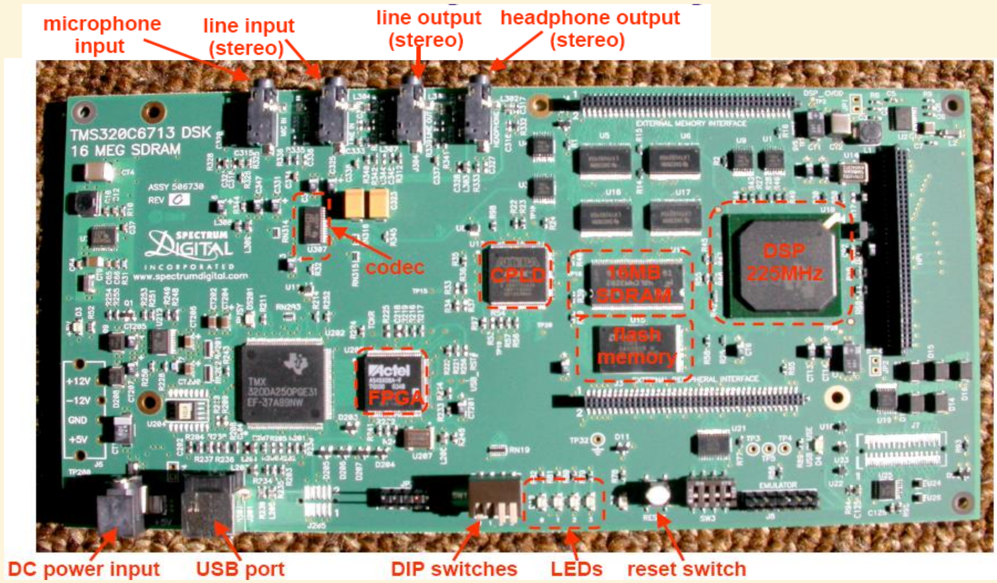
kraj_biet@yahoo.com

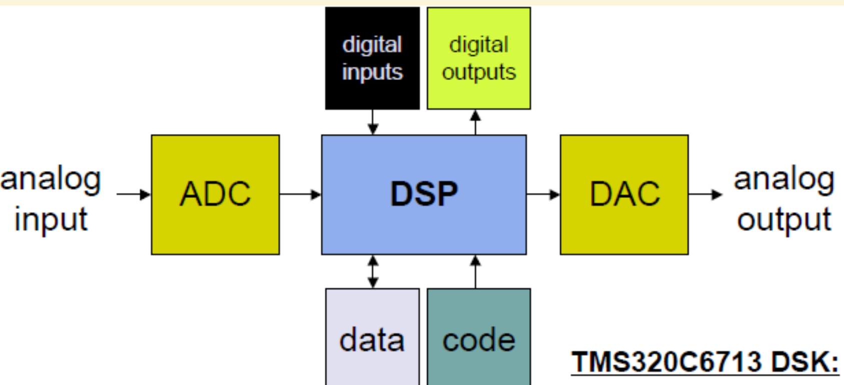
Design and Implementation of Systems

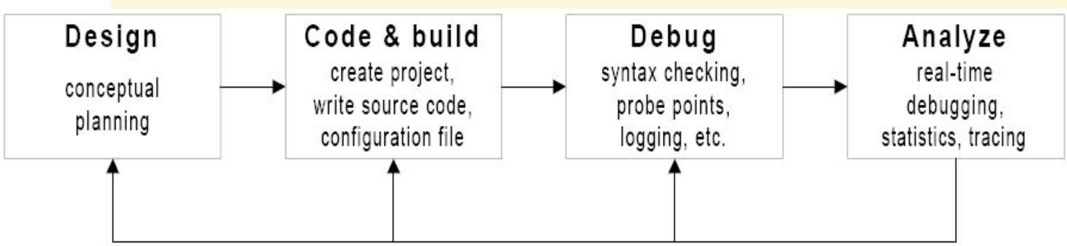
C6713 DSK Functional Block Diagram



C6713 DSK Physical Layout

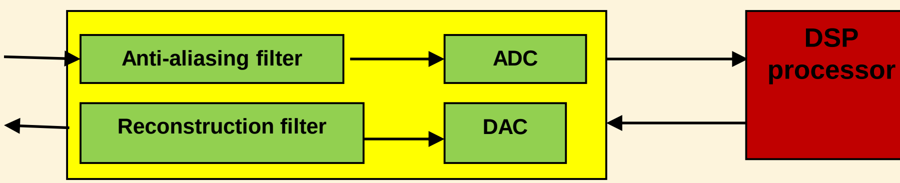






TMS320C6713 DSK:
digital inputs = 4 DIP switches
digital outputs = 4 LEDs
ADC and DAC = AIC23 codec

Interfacing with real world



CODEC

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- Digital Signal Processing (DSP) .
- Digital Filters:
- For appropriate reduction in power consumption and improvement in speed :Structures (Direct Form, Data broadcast, Cascade, Parallel and Transposed)
- Major factors for Selection of specific realization : computational complexity, memory requirements and finite word length effect [1].
- due to its absolute stability and linear-phase property FIR filters find extensive applications in mobile communication
- for channel Equalization, matched filtering, and pulse shaping.
- The complexity of FIR filter is mainly dominated by coefficient multiplication operation.

$$y[n] = \sum_{k=0}^{N-1} C_k\, x[n-k]$$

Performance Analysis?

efforts towards developing algorithms for efficient implementation of FIR filters on Application Specific Integrated Circuit (ASIC) and Field programming gate Array (FPGAs)

- The core of the convolution is the multiplication operation,:efficient algorithm to optimize the cost of multiplication

Multiple Constant Multiplication (MCM) approach. This method replaces all traditional multipliers by an MCM block following the transposed direct form structure

Numerical transformation techniques for reducing the complexity of computation. These transformations rely upon subexpression elimination to restructure the computation

Common Subexpression Elimination (CSE) method : to optimize the cost of multiplication

For further elimination in redundancy: Modified Iteration Matched (MITM) that efficiently performs bitwise match and then uses the pattern corresponding to the best match

MCM and MITM approaches :using basic binary number representation and Canonical signed digit (CSD)representation.

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Algorithm to obtain CSD representation:

$A' = a'_{w-1}.a'_{w-2}.\dots\dots.a'_1.a'_0$, = 2's complement number

Its CSD representation is $A = a_{w-1}.a_{w-2}.\dots\dots.a_1.a_0$,

$a'_{-1} = 0;$

$g_{-1} = 0;$

$a'_W = a'_{W-1};$

$for\ (i = 0\ to\ W-1)$

{

$qi = a'_i \oplus a'_{i-1};$

$gi = \overline{g\iota - 1}qi;$

$a_i = (1 - 2a'_{i+1})g_i;$

}

Algorithm : for **MCM** uses an iterative matching process :

Step.1 To express each constant (coefficient) in the set using a binary format (such as signed, unsigned, 2's complement representation).

Step.2 Determine the number of bit-wise matches (nonzero bits) between all of the constants in the set.

Step.3 Choose the best matches bitwise of these filter coefficients.

Step.4 Eliminate the redundancy from the best match bits.

Step.5 Return the remainders and the redundancy to the set of coefficients.

Step.6 Repeat Steps 2-4 until no improvement is achieved.

The **algorithm for MITM** uses a modified iterative matching process that consists of the following steps:

Step.1- normalize the filter coefficients and represent them in CSD form by applying CSD algorithm.

Step.2- find and eliminate any repetition of any constant and determining the number of bit-wise matches (nonzero bits)

Step.3- calculating the number of nonzero bits for all pairs of constants

Step.4- Choose the best matches

Step.5- The selected set of bits is based on criteria such as, its having the maximum number of bitwise matches and having the minimum number of nonzero bits. The set of bits used for choose the coefficients and applying the function of comparing.

Step.6- eliminate the redundancy of the filter coefficient by using shift and inverting the set of bits

Step.7- After finding the best match, the set of coefficient is updated

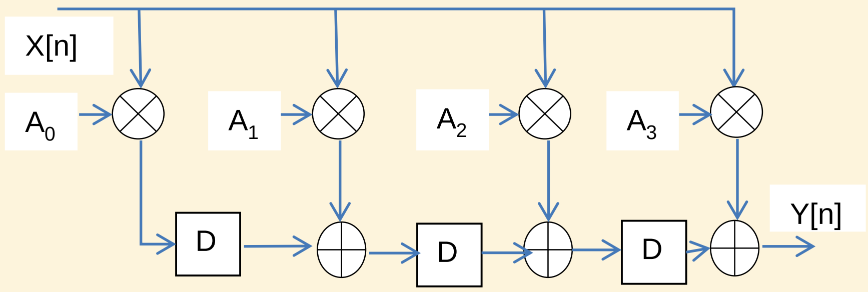
Step.8- Return the remainders and redundancy bits of the entire coefficients.

Step.9- Repeat Steps 2-8 until the iteration condition allows the algorithm to find common patterns amongst constants while at least one adder/subtractor can be saved.

FIR1 filter design

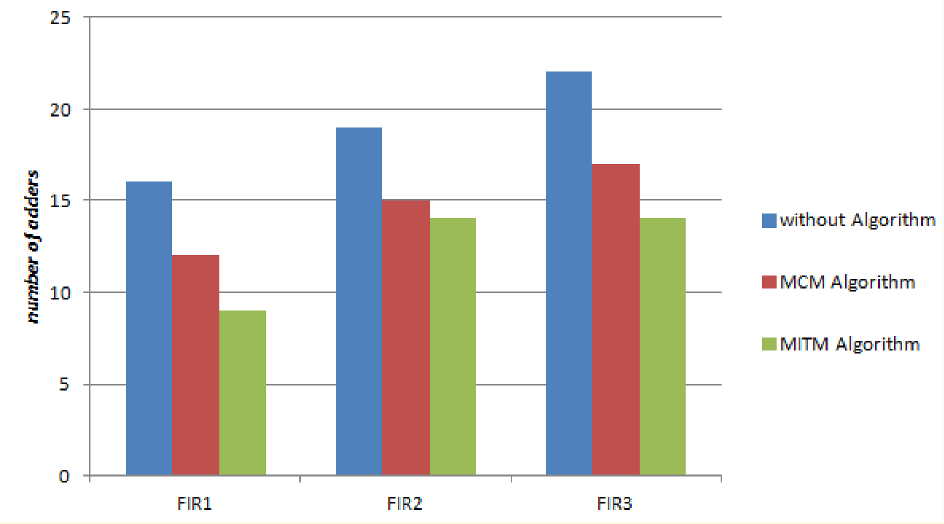
Consider the 4- tap FIR1 filter

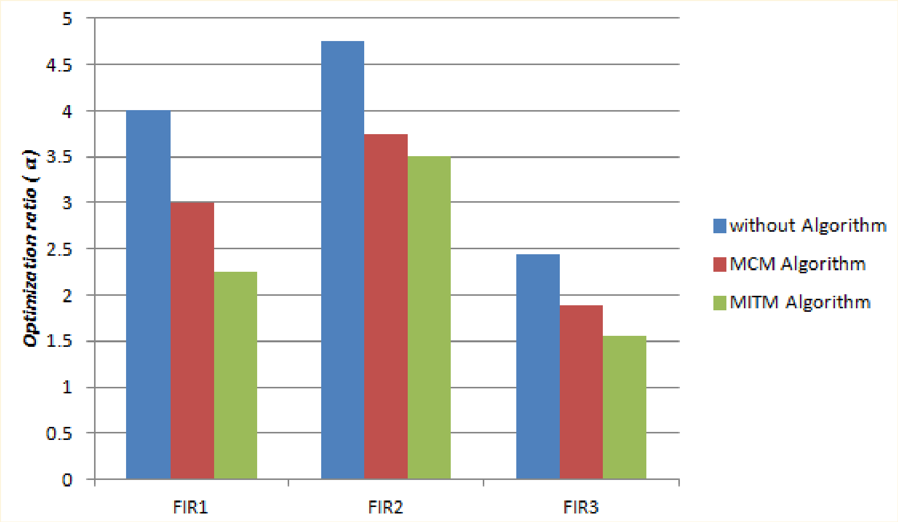
$$y(n) = 281x(n) + 665x(n-1) + 206x(n-2) + 200x(n-3)$$



The transposed structure of an FIR filter of order =3.

Filter	Algorithm	Adder (M)	Shifter	Optimization ratio	improvement ratio
FIR N=4 W=10	without algorithm	16	15	4.00	1.00
	MCM	12	8	3.00	1.33
	MITM	9	8	2.25	1.77





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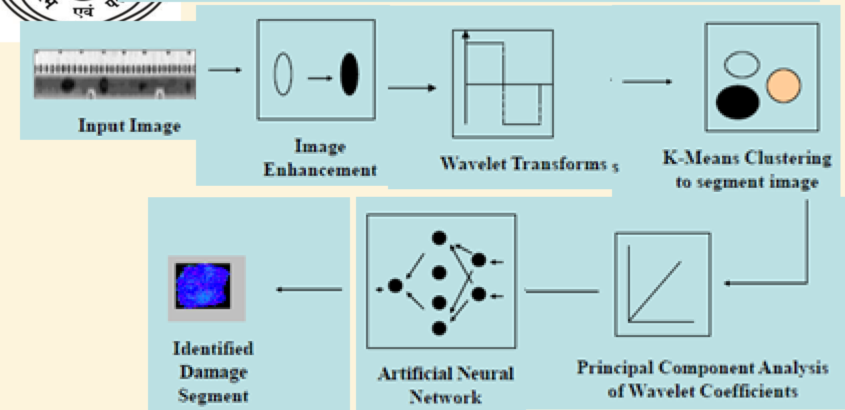
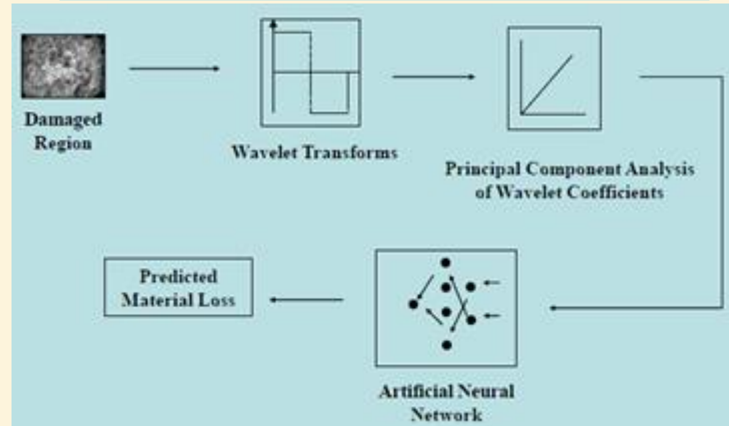
Identification Process

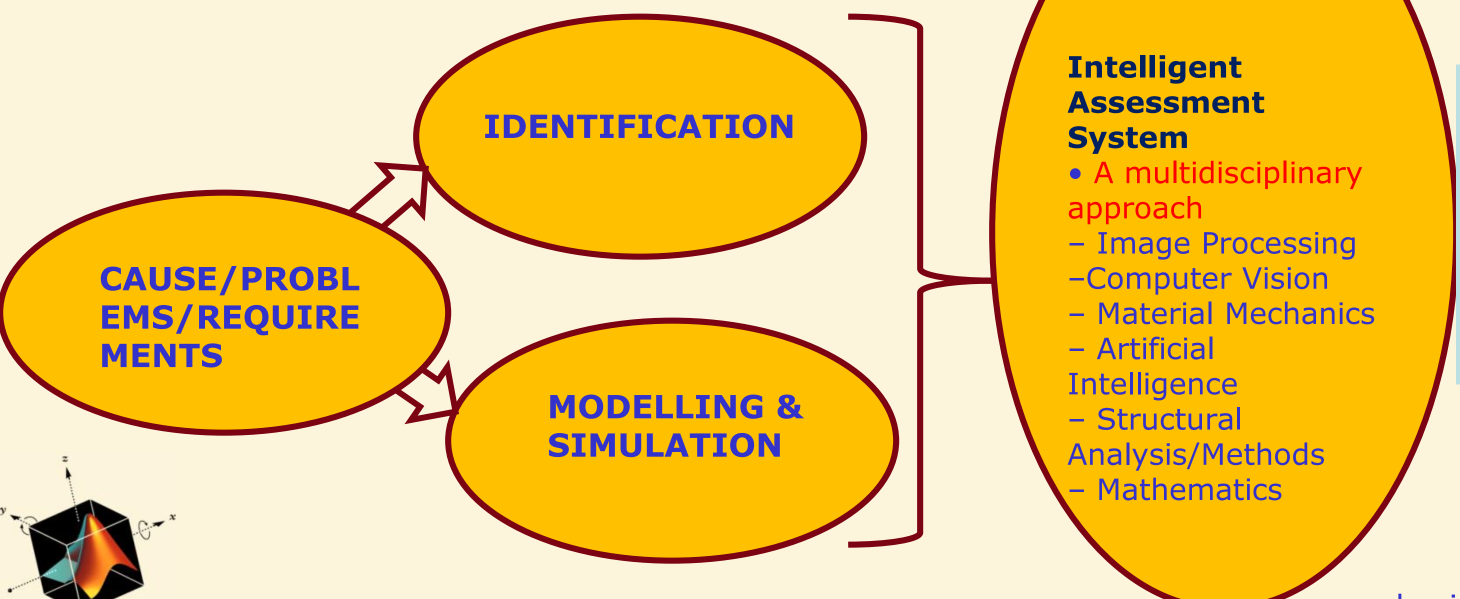


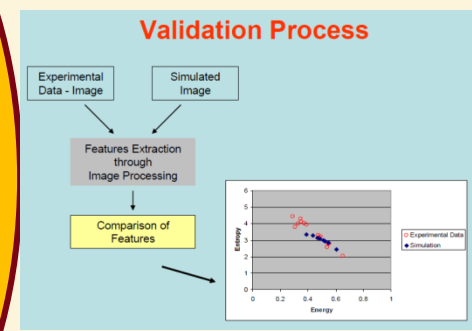
Quantification Process



IMPLEMENTATION

Computational Intelligence Methods





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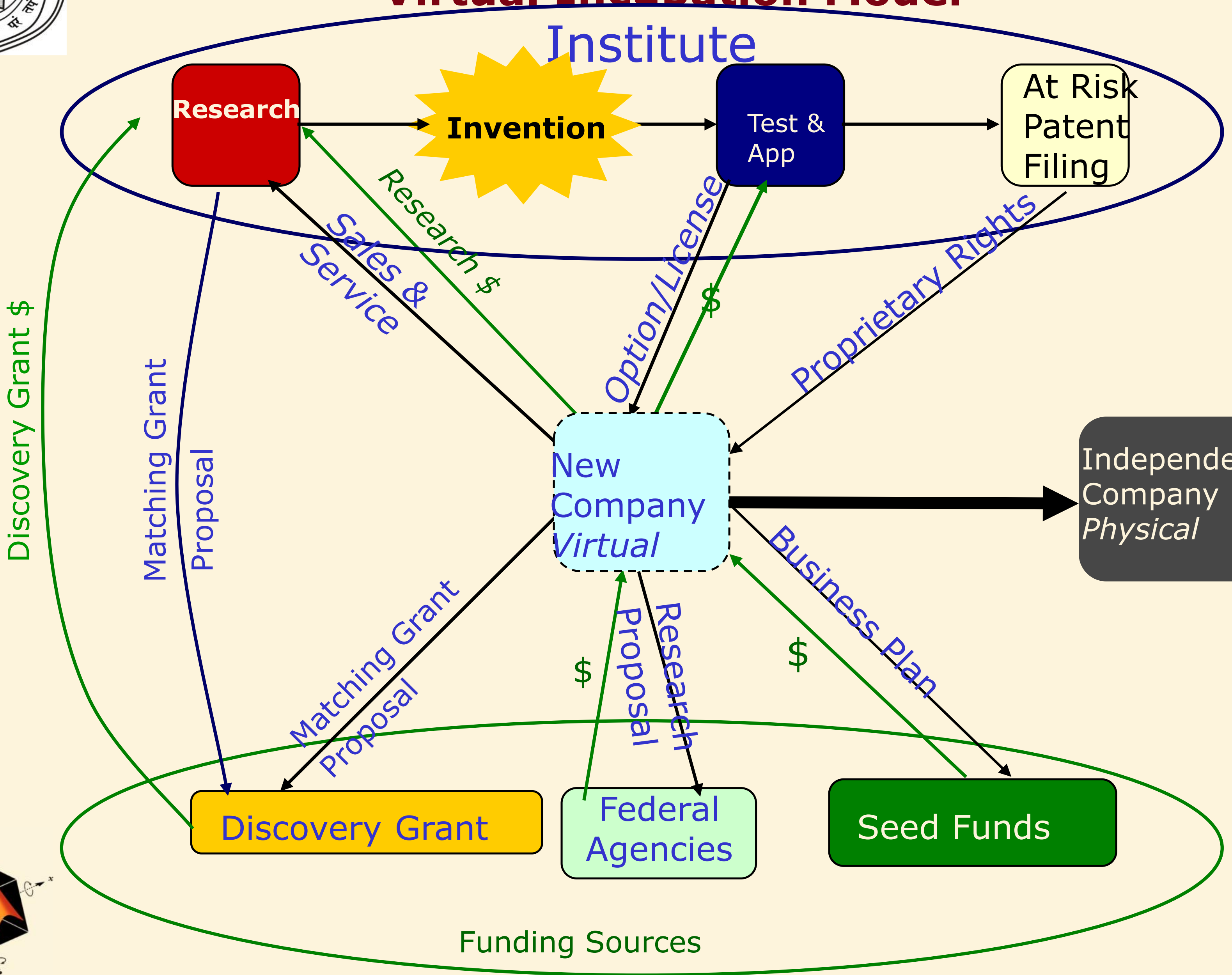
Virtual Incubation Model



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kraj_biet@yahoo.com