DESIGN OF LOW-DENSITY PARITY-CHECK CODES FOR USE WITH MAGNETIC RECORDING

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Disk drive picture taken from http://www.maxtor.com

Error-Correcting Codes For Disk Drives

- Higher density magnetic recording means higher noise levels
- Better error-correcting codes (ECC) needed

Low-Density Parity-Check (LDPC) Codes

- Developed by R. Gallager in 1962 but mostly forgotten, partly because decoding too CPU intensive
- Typical CPU of the time capable of c. 100 floating point calculations per second

Low-Density Parity-Check (LDPC) Codes

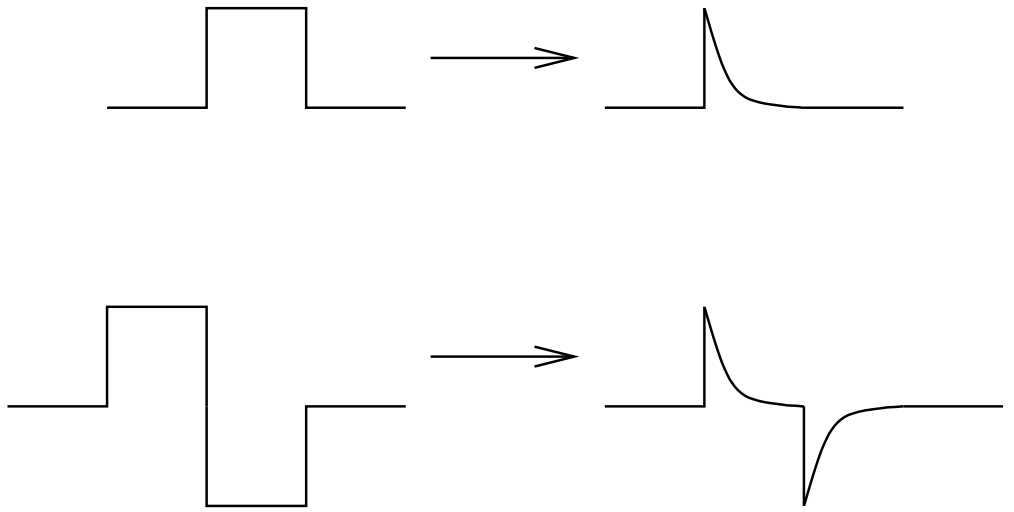
- Rediscovered by D.J.C.MacKay/R. Neal 1995; now more practical because of faster CPUs
- Today: Pentium 4 capable of billions of calculations per second
- LDPC codes amongst most powerful error-correcting codes currently known

Designing Good LDPC Codes

- T.Richardson, R.Urbanke developed density evolution method, 2000
- Designing codes by studying probability densities of so-called L variables
- For white-noise-only channel, their code only 0.0045dB worse than theoretical limit (compared to previous codes at c. 3dB)

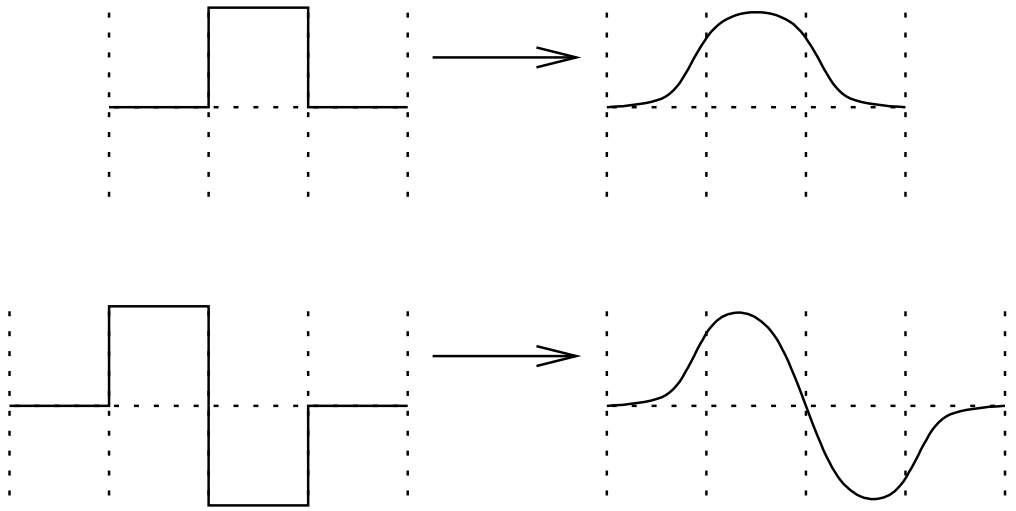
Memoryless Channels

- For simple memoryless communication channels the output from a given input bit does not affect that from other bits:



Channels with Memory – Inter-Symbol Interference

- For channels with memory, the output from a given bit **interferes** with that from other bits, so-called inter-symbol interference (ISI)

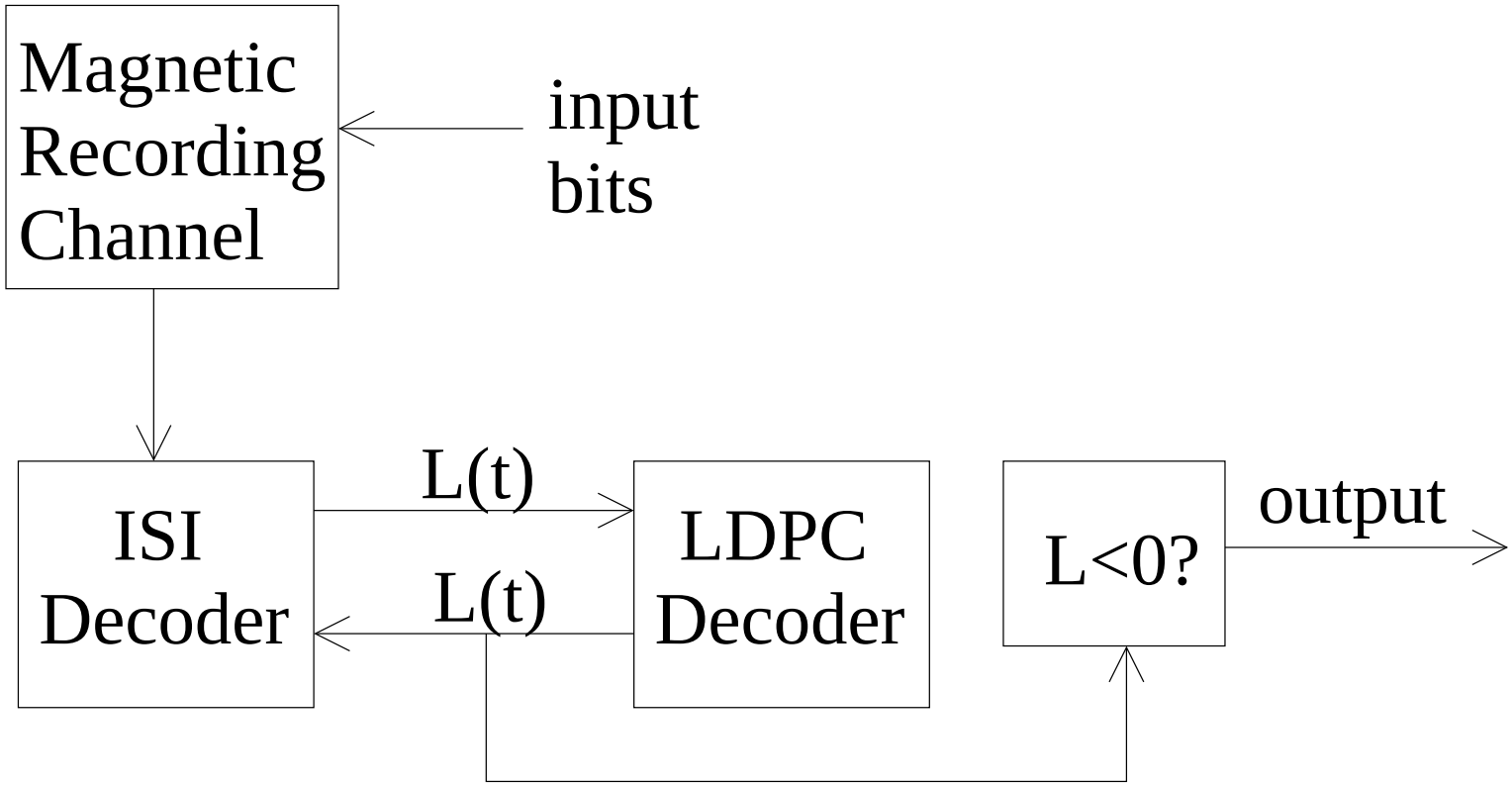


Problem

- Richardson/Urbanke method only works for memoryless channels, i.e., systems without ISI
- Magnetic recording (e.g., on disk drives) has massive ISI!

Handling ISI in Magnetic Recording

- Magnetic recording systems need both an ECC decoder and an ISI decoder



Density Evolution for ISI Decoder

- To design codes, must study probability densities of variables inside ISI decoder
- Combined with Richardson/Urbanke analysis of ECC, we can search for good codes

Computational Burden

- Richardson/Urbanke algorithm alone can take 1-2 weeks on Pentium II/400MHz
- Density evolution for ISI decoder even worse: months of CPU time!

How High Performance Computing Can Help

- Better computational resources needed
- Both Richardson/Urbanke and ISI density evolution are highly parallelizable algorithms
- Computations suited to highly parallel cluster