An Algorithm to Design Prescribed Length Codes for Single-Tracked Shaft Encoders

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Outline

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Problem statement

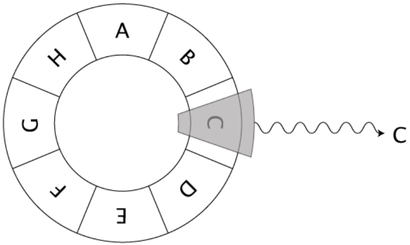
Problem

Design shaft encoders with any desired resolution

shaft encoder $\equiv$ digital absolute shaft encoder

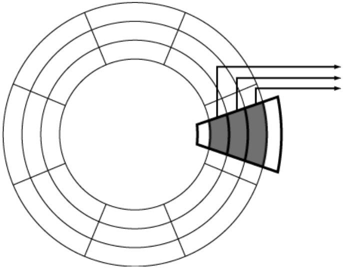
Applications: aerospace, aviation, computer-aided machinery, semiconductor manufacturing, robotics, medical imaging, telescopes...

Encoder diagrams



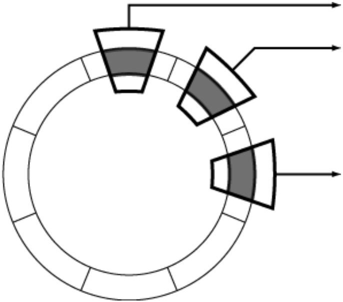
Conceptual shaft encoder

Encoder diagrams



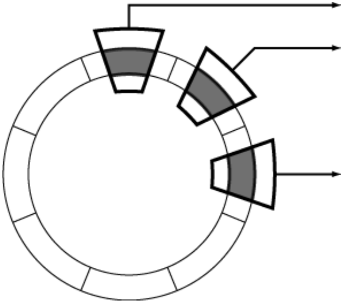
Multi-tracked shaft encoder

Encoder diagrams



Single-tracked shaft encoder

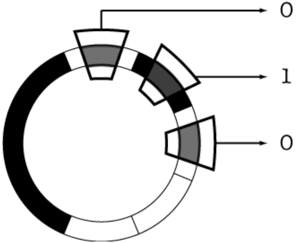
Encoder diagrams



Single-tracked shaft encoder

Gain: reduction of moving mass

Construction of single-tracked encoders



Parameters:

- q: detector's arity ($q = 2$)
- e: desired resolution ($e = 8$)
- n: number of detectors ($n = 3$)

Problem

Construct a (q, n, e)-closed sequence (with $n \geq \lceil \log_q e \rceil$)

Fact

Maximal LFSRs can generate such sequences when $e = q^n - 1$ and $q = p^m$ for some prime p and integer $m > 0$

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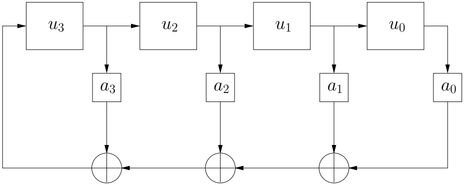
Idea behind the solution



Use sequences generated by non-maximal LFSR

Connection and seed polynomials:

$$a(x) = x^4 - (a_3x^3 + a_2x^2 + a_1x + a_0) \in \mathbb{F}_q[X]$$
$$u(x) = u_3x^3 + u_2x^2 + u_1x + u_0 \in \mathbb{F}_q[X]$$

Parameters:

- q: detector's arity – size of the field
- e: desired resolution – length of the sequence
- n: number of detectors – degree of $a(x)$

Main result

Problem

Given q and e, find a polynomial $a(x) \in \mathbb{F}_q[X]$ of order e and minimal degree n.

Theorem

This problem can be solved algorithmically

Fact

Using the solution $a(x)$ as connection polynomial and $u(x) = 1$ as seed polynomial, the resulting LFSR generates a (q, n, e)-closed sequence

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About our solution

Benefits:

- Works “out of the box” with q-ary detectors and *any* resolution
- Minimizes the number of detectors required among all sequences generated by a LFSRs
- Algorithmically efficient in practice
- Avoids extra circuitry used by previously proposed solutions

Drawbacks:

- May use more detectors than strictly necessary
- Generated codes do not satisfy Gray property

Future work

- Build a real implementation
- Estimate the number of extra detectors required
- Use the redundancy in the code for error correction purposes
- Generalize the theory to non-linear feedback logics

Questions?