Electric piano

ICCP 2015

Delft University of Technology

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Outline

Next Subsection

1. First Section
   - Section 1 - Subsection 1
   - Section 1 - Subsection 2
   - Section 1 - Subsection 3
2. Second Section
   - Section 2 - Subsection 1
   - Section 2 - Last Subsection

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The wave equation

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2} - \kappa^2 \frac{\partial^4 y}{\partial x^4} - 2b_1 \frac{\partial y}{\partial t} + 2b_2 \frac{\partial^3 y}{\partial x^2 \partial t}$$

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$$y_n^{t+1} = a_1 \left(y_{n+2}^t + y_{n-2}^t\right) + a_2 \left(y_{n+1}^t + y_{n-1}^t\right) + a_3 y_n^t$$
$$+ a_4 y_n^{t-1} + a_5 \left(y_{n+1}^{t-1} + y_{n-1}^{t-1}\right)$$

Section 1 - Subsection 1 - Page 2

Definition

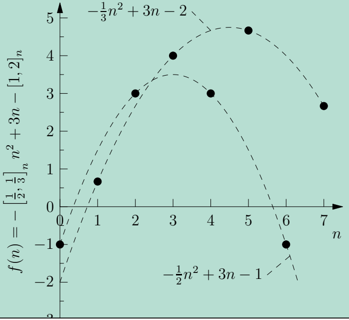
Let n be a discrete variable, i.e. $n \in \mathbb{Z}$. A 1-dimensional periodic number is a function that depends periodically on n.

$$u(n) = [u_0, u_1, \ldots, u_{d-1}]_n = \begin{cases} u_0 & \text{if } n \equiv 0 \pmod{d} \\ u_1 & \text{if } n \equiv 1 \pmod{d} \\ \vdots & \\ u_{d-1} & \text{if } n \equiv d-1 \pmod{d} \end{cases}$$

d is called the period.

Example

$$
\begin{aligned}
f(n) &= -\left[\tfrac{1}{2}, \tfrac{1}{3}\right]_n n^2 + 3n - [1,2]_n \\
&= \begin{cases} -\frac{1}{3}n^2 + 3n - 2 & \text{if } n \equiv 0 \pmod 2 \\ -\frac{1}{2}n^2 + 3n - 1 & \text{if } n \equiv 1 \pmod 2 \end{cases}
\end{aligned}
$$



Section 1 - Subsection 1 - Page 4

Definition

A polynomial in a variable x is a linear combination of powers of x:

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A quasi-polynomial in a variable x is a polynomial expression with periodic numbers as coefficients:

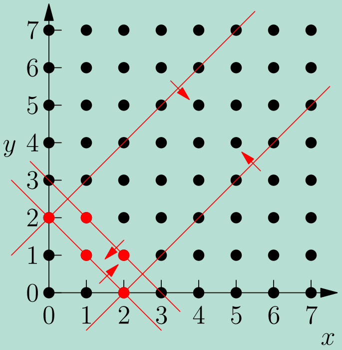
$$f(n) = \sum_{i=0}^{g} u_i(n) n^i$$

with $u_i(n)$ periodic numbers.

Next Subsection

Section 1 - Subsection 2 - Page 1

Example



$x + y \leq p$

p	$f(p)$
3	5

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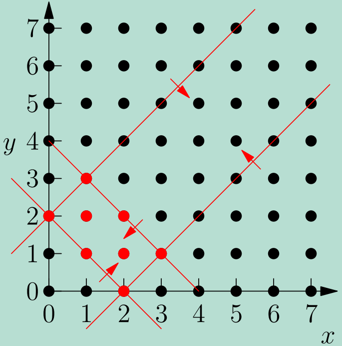
Example



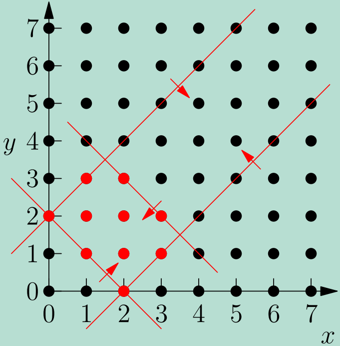
$p = 4$

$x + y \leq p$

p	$f(p)$
3	5
4	8

Section 1 - Subsection 2 - Page 1

Example

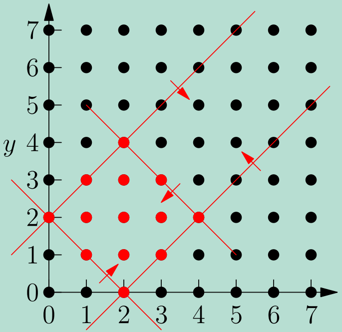


$p = 5$

$x + y \leq p$

p	$f(p)$
3	5
4	8
5	10

Example



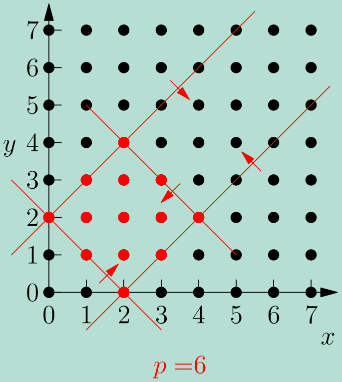
$p = 6$

$x + y \leq p$

p	$f(p)$
3	5
4	8
5	10
6	13

Section 1 - Subsection 2 - Page 1

Example



$$x + y \leq p$$

p	$f(p)$
3	5
4	8
5	10
6	13

$$\frac{5}{2}p + \left[-2, \frac{-5}{2}\right]_p$$

Section 1 - Subsection 2 - Page 2

- The number of integer points in a parametric polytope P_p of dimension n is expressed as a piecewise a quasi-polynomial of degree n in p (Clauss and Loechner).

Section 1 - Subsection 2 - Page 2

- The number of integer points in a parametric polytope P_p of dimension n is expressed as a piecewise a quasi-polynomial of degree n in p (Clauss and Loechner).
- More general polyhedral counting problems:
  Systems of linear inequalities combined with $\vee, \wedge, \neg, \forall$, or $\exists$ (Presburger formulas).

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Section 1 - Subsection 2 - Page 2

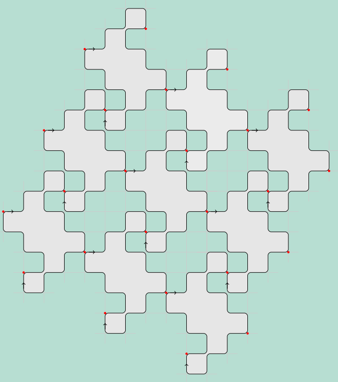
- The number of integer points in a parametric polytope P_p of dimension n is expressed as a piecewise a quasi-polynomial of degree n in p (Clauss and Loechner).
- More general polyhedral counting problems:
  Systems of linear inequalities combined with $\vee, \wedge, \neg, \forall$, or $\exists$ (Presburger formulas).
- Many problems in static program analysis can be expressed as polyhedral counting problems.

Next Subsection

Section 1 - Subsection 3 - Page 1

A picture made with the package TiKz

Example



Next Subsection

Section 2 - subsection 1 - page 1

Alertblock

This page gives an example with numbered bullets (enumerate) in an "Example" window:

Example

Discrete domain $\Rightarrow$ evaluate in each point

Not possible for

1. parametric domains

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Section 2 - subsection 1 - page 1

Alertblock

This page gives an example with numbered bullets (enumerate) in an "Example" window:

Example

Discrete domain $\Rightarrow$ evaluate in each point

Not possible for

1. parametric domains
2. large domains (NP-complete)

Next Subsection

Last Page

Summary

End of the beamer demo
with a *tidy* TU Delft lay-out.
Thank you!