



Meta programming

Metaprograming

- What is it?
Write programs that
manipulate/generate other programs
- Example: a C language compiler
- Language of meta-program: (Maple)
Metalanguage or source language
- Language of generated programs: (C)
object/target language

Advantages of metaprogramming

- Automate the massive production of code (generate millions of lines of code)
- Easy maintenance of code
- Easier debugging process
- Use the Maple symbolic engine to manipulate mathematical expressions fast and reliably
- Deal efficiently with problems depending on parameters

Elementary Symmetric Functions (ESF) in n variables

$$e_1(X_1, X_2) = X_1 + X_2,$$

$$e_2(X_1, X_2) = X_1X_2.$$

$$e_1(X_1, X_2, X_3) = X_1 + X_2 + X_3,$$

$$e_2(X_1, X_2, X_3) = X_1X_2 + X_1X_3 + X_2X_3,$$

$$e_3(X_1, X_2, X_3) = X_1X_2X_3.$$

$$e_1(X_1, X_2, X_3, X_4) = X_1 + X_2 + X_3 + X_4,$$

$$e_2(X_1, X_2, X_3, X_4) = X_1X_2 + X_1X_3 + X_1X_4 + X_2X_3 + X_2X_4 + X_3X_4,$$

$$e_3(X_1, X_2, X_3, X_4) = X_1X_2X_3 + X_1X_2X_4 + X_1X_3X_4 + X_2X_3X_4,$$

$$e_4(X_1, X_2, X_3, X_4) = X_1X_2X_3X_4.$$

2nd ESF

- Restrict all variables to take values in $\{-1,+1\} \rightarrow 2^n$ cases

- Consider the 2nd ESF:

- It contains $N = n(n-1)/2$ quadratic monomials

- Therefore, the max value is N

- What is the minimum value?

$$\sum_{1 \leq i < j \leq n} x_i x_j$$

Naïve approach

- Write a C program for $n=3$. compile it and execute it, record the result.
- Write a C program for $n=4$, compile it and execute it, record the result.
- Write a C program for $n=5$, compile it and execute it, record the result.
- **Hope: identify** some pattern for the minimum value and then **prove** it.

Metaprogramming approach:

- Abstract the **common features** of the C programs for $n = 3, 4, 5$
- Write a Maple meta-program that will **generate automatically** a C program to solve this minimization problem for the 2nd ESF, for an **arbitrary** but **fixed** value of the parameter n
- Use the meta-program to generate several C programs, compile and execute them, **using a bash shell script of course!**