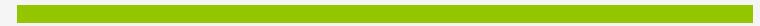


Meta programming



Metaprogramming

- What is it?

Write programs that
manipulate/generate other programs

- Example: a C language compiler
- Language of meta-program: (Maple)
Metalinguage 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

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

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

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

$$e_2(X_1, X_2, X_3) = X_1 X_2 + X_1 X_3 + X_2 X_3,$$

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

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

$$e_2(X_1, X_2, X_3, X_4) = X_1 X_2 + X_1 X_3 + X_1 X_4 + X_2 X_3 + X_2 X_4 + X_3 X_4,$$

$$e_3(X_1, X_2, X_3, X_4) = X_1 X_2 X_3 + X_1 X_2 X_4 + X_1 X_3 X_4 + X_2 X_3 X_4,$$

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

2nd ESF

- Restrict all variables to take values in $\{-1,+1\}$ → 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!**