Acyclic Visitor Pattern in Formulation of Mathematical Model

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Contents

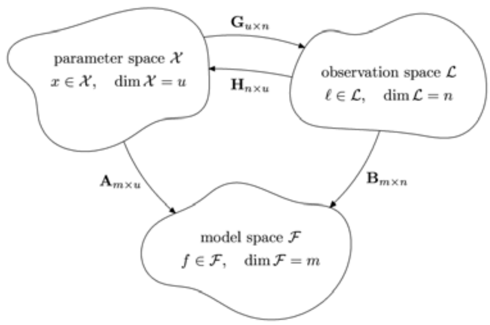
Mathematical model

• general formulation of the functional relation between the unknown parameters and observed quantities is discussed in *Geodesy: The Concepts* by Vanicek and Krakiwsky

• three main components of mathematical model:
  • parameter space
  • observation space
  • model space

• relations between parameter, observation and model spaces.

Mathematical model - linear relations between parameter, observation and model spaces



Main problem

how to implement a set of classes describing linear relations between parameter, observation and model spaces in C++ language and define polymorphic functions like

```
observation->derivation(parameter);
```

where we need to select from `MxN` virtual functions.

Class Parameter

Class `Parameter` represents ***unknown parameter*** and contains these information:
  • initial value
  • correction (correction of parameter – from least squares adjustment)
  • correspondent number of column in coefficient matrix
  • type of parameter (unused, free, constrainded, ...).

Class `Parameter` has list of other parameters on which is given *parameter* dependent.

Class Observation

- every type of observation has (his own) list of parameters
- linearization of observation is performed by set of partial derivatives of the functions with respect to the elements of list of parameters
- member function which represented linearization was changed

“Procedural” pattern

- two dimensional array of pointers to function of analytic derivations
- dimension 1 represents observations
- dimension 2 represents parameters
- two enumeration types:
  - enumeration type `type_observation` – named constants represents type of observations
  - enumeration type `type_parameter` - named constants represents type of parameters

“Procedural” pattern - example

```
enum type_observation {
      obsDistance = 0,
      obsAngle,
      e_number_of_observations };

  enum type_parameter {
      paramB = 0,
      paramL,
      paramH,
      e_number_of_parameters };

  typedef double (*derivation)(Observation*);

  double derivation_distance_L(Observation* obs);

  derivation ListDerFun[e_number_of_observations]
                       [e_number_of_parameters  ] =  { 0 };

  ListDerFun[obsDistance][paramL] = derivation_distance_L;
  ListDerFun[obsAngle   ][paramH] = derivation_angle_H;
```


“Visitor” pattern

- the base class of visitor hierarchy – abstract base class `Parameter`, which represents “visitor“
- class `Parameter` contains pure virtual member function `virtual double Parameter::deriveXX(XX&) = 0`
- every new *parameter* have to be derived from the class `Parameter` and rewrote all member function `deriveXX` for all observations
- class `Observation` has defined only one pure virtual function `virtual double Observation::derivation(Parameter& v) = 0`

“Visitor” pattern - example

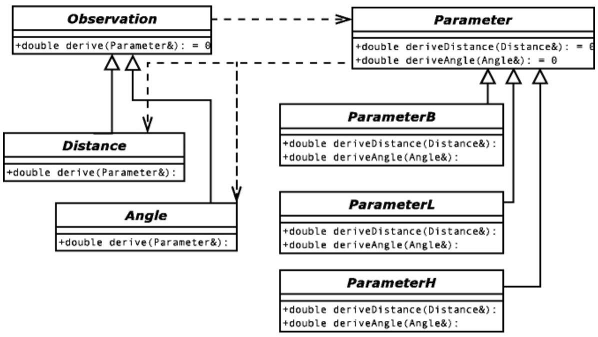
```
class Parameter {
   public:
         virtual double deriveDistance (Distance&) = 0;
         virtual double deriveAngle    (Angle&)    = 0;   };

 class ParameterB : public Parameter {
   public:
         double deriveDistance (Distance&) { return 10; }
         double deriveAngle    (Angle&   ) { return 20; } };

 class ParameterL : public Parameter {
   public:
         double deriveDistance (Distance&) { return 30; }
         double deriveAngle    (Angle&   ) { return 40; } };

 class Observation {
 public: virtual double derive(Parameter& v) = 0; };

 class Distance: public Observation {
 public:
     double derive(Parameter& v)
     { return v.deriveDistance(*this); } };
```

“Visitor” pattern disadvantages

- we have a cycle of dependencies that causes `Observation` to transitively depend upon all its derivatives
- when adding a new observation type (derived from class `Observation`) the `Parameter` class and all its derived subclasses need to be rewritten (add new virtual function)
- we have to define appropriate virtual function in all descendants classes of the class `Parameter`, clearly not all geodetic models need to define linearization for all observation types.

“ Acyclic Visitor” pattern

- “Acyclic Visitor“ pattern can avoid most of the major drawbacks of using the “Visitor” pattern or procedural pattern
- problems were solve by using multiple inheritance and `dynamic_cast`
- role of “visitor“ has degenerate class `Parameter` in this pattern
- we have to define abstract classes of derivations `DeriveXX` for every class (type of observation) derived from the class `Observation`, these classes have only pure virtual function `virtual double derive(Angle*)=0;`

“Acyclic Visitor” pattern - definition of new type of observation

When we need to add a new type of observations (by derivating from abstract class `Observation`) we have to define member function `double derivation(Parameter* v):`

```
double Distance::derivation(Parameter* v)
{
    DeriveDistance* ad = dynamic_cast<DeriveDistance*>(v);

    if (ad)
        return ad->derive(this);
    else
        ; // error handling
}
```


“Acyclic Visitor” pattern - example

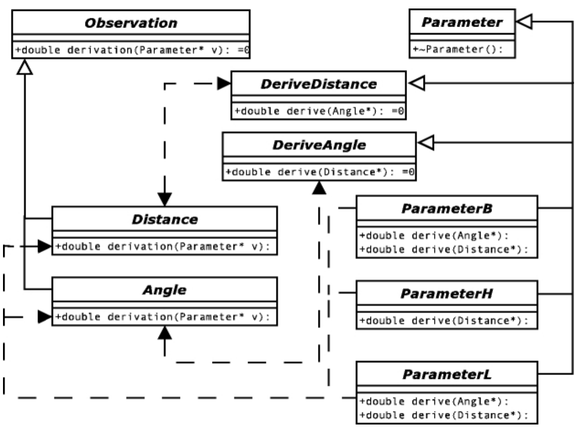
```
class Parameter
{ public: virtual ~Parameter() {} };

class Observation {
public: virtual double derivation(Parameter* v) = 0; };

class Angle;
class DeriveAngle
{ public: virtual double derivation(Angle*) = 0; };

class Distance;
class DeriveDistance
{ public: virtual double derivation(Distance*) = 0; };

class ParameterB : public Parameter,
                   public DeriveDistance,
                   public DeriveAngle
{
  public:
        double derivation(Distance*);
        double derivation(Angle*    );
};
```

“Acyclic Visitor” pattern advantages

- when we want define for example, analytic derivation of observation `Angle` by parameter `ParameterH`, we have to only the class `ParameterH` derive from class `Observation` and from class `DeriveAngle` and define virtual member function
  `double ParameterH::derive(Angle*)`
- we can not define analytic derivations for all combination observations-parameters (contrast with “Visitor” pattern)
- the main advantage of the acyclic visitor pattern is that when defining a new observation type or a new model, the existing software is not affected (no dependency cycles)

Conclusion

The main advantage of the acyclic visitor pattern is that when defining a new observation type or a new model, the existing software is not affected (no dependency cycles). This design enables highly general level of abstraction in a software implementation of the matematical model.

Thank you for your attention.