

《计算概论A》课程 程序设计部分 指针(2)

李 戈 北京大学信息科学技术学院 lige@sei.pku.edu.cn

本节内容

- ■字符串与指针
- ■指向二维数组的指针
 - ◆ 再谈一维数组的地址
 - ◆ 指向二维数组的指针
 - ◆ 利用指针遍历二维数组

字符串与指针

- ■指向数组的指针
 - int a[10]; int *p; p = a;
- ■指向字符串的指针
 - ◆ 指向字符串的指针变量:
 - char a[10]; char *p; p = a;

字符串指针举例

请说明一下程序完成了什么任务:

```
#include<iostream>
                                      string a is :How are you?
#include <iomanip>
                                      string b is :How are you?
using namespace std;
int main()
  char a[] = "How are you?", b[20];
  char *p1, *p2;
  for (p1 = a, p2 = b; *p1 != '\0'; p1++, p2++)
     p2 = p1;
  *p2 = '\0';
  cout << "string a is :" << a << endl;
  cout << "string b is :" << b << endl;
  return 0;
```

```
int main()
  int a = 5;
  int *pa = &a;
  int b[6] = \{1, 2, 3, 4, 5, 6\};
  int *pb = b;
  char c[6] = \{'h', 'e', 'l', 'l', 'o', '\setminus 0'\};
  char *pc = c;
  cout<< a <<endl:
                                  0x0013FF7C
  cout<< pa <<endl<<endl;
  cout<< b <<endl:
                                  0x0013FF60
  cout<< pb <<endl;
                                  0x0013FF60
  cout<< c <<endl;
                                  hello
  cout<< pc <<endl;
                                  hello
  return 0;
```

```
int main()
  int a = 5;
  int *pa = &a;
  int b[6] = \{1,2,3,4,5,6\};
  int *pb = b;
  char c[6] = \{'h', 'e', 'l', 'l', 'o', '\setminus 0'\};
  char *pc = c;
  cout<< a <<endl;
                                          0x0013FF7C
  cout<< pa <<endl<<endl;
                                          0x0013FF60
  cout<< b <<endl;
  cout<< pb <<endl<
                                           0x0013FF60
                                          0x0013FF54
  cout<<static_cast<void*>(c)<<endl;
  cout<<static_cast<void*>(pc)<<endl;
                                          0x0013FF54
  return 0;
```

字符串指针举例

```
#include<iostream>
using namespace std;
int main()
  char buffer[10] = "ABC";
  char *pc;
  pc = "hello";
  cout << pc << endl;
  pc++;
  cout << pc << endl;
  cout << *pc << endl;
  pc = buffer;
  cout << pc;
  return 0;
```



字符串指针举例

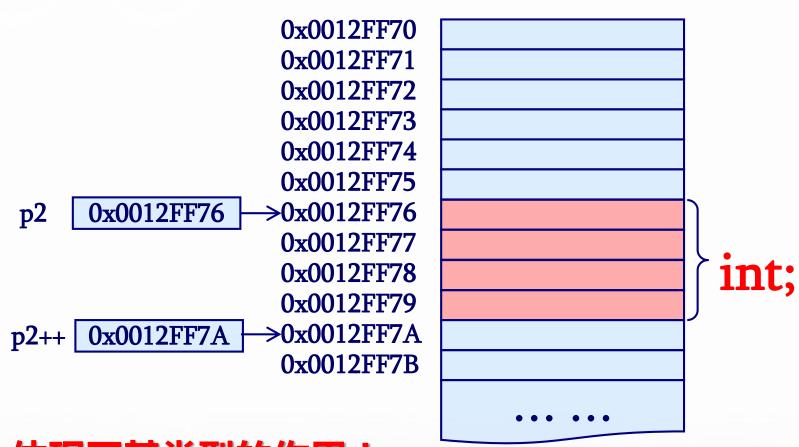
```
#include<iostream>
using namespace std;
int main()
  char buffer[10] = "ABC";
  char *pc;
  pc = "hello";
  cout << pc << endl;
  pc++;
  cout << pc << endl;
  cout << *pc << endl;
  pc = buffer;
  cout << pc;
  return 0;
```



本节内容

- ■字符串与指针
- ■指向二维数组的指针
 - ◆ 再谈─维数组的地址
 - ◆ 指向二维数组的指针
 - ◆ 利用指针遍历二维数组

pointer++ 的含义



体现了基类型的作用!

再谈一维数组的地址

```
#include<iostream>
using namespace std;
int main()
  int a[4] = \{1, 3, 5, 7\};
  cout << a << endl;
  cout \ll a + 1 \ll endl;
  cout \ll &a \ll endl;
  cout << &a + 1 << endl;
  cout << *(&a) << endl;
  cout << *(&a) +1 << endl;
  return 0;
```

0028F7C2		
0028F7C3		
0028F7C4		
0028F7C5	1010	
0028F7C6	a[0]	
0028F7C7		
0028F7C8		
0028F7C9	ر11	
0028F7CA	a[1]	
0028F7CB		
0028F7CC		
0028F7CD	a[2]	
0028F7CE	ا مرکا	
0028F7CF		
0028F7D0		
0028F7D1	a[3]	
0028F7D2	alsi	
0028F7D3		
0028F7D4		
0028F7D5		
0028F7D6		
0028F7D7		
0028F7D8		
0028F7D9		

数组的地址

§6.2.5 Types

An array type describes a contiguously allocated nonempty set of objects with a particular member object type, called the *element type*. The element type shall be complete whenever the array type is specified. Array types are characterized by their element type and by the number of elements in the array. An array type is said to be derived from its element type, and if its element type is T, the array type is sometimes called "array of T". The construction of an array type from an element type is called "array type derivation".

§6.3.2.1 Lvalues, arrays, and function designators

Except when it is the operand of the sizeof operator, the _Alignof operator, or the unary & operator, or is a string literal used to initialize an array, an expression that has type "array of type" is converted to an expression with type "pointer to type" that points to the initial element of the array object and is not an Ivalue. If the array object has register storage class, the behavior is undefined.

§6.5.2.1 Array subscripting

A postfix expression followed by an expression in square brackets [] is a subscripted designation of an element of an array object. The definition of the subscript operator [] is that E1 [E2] is identical to (*(E1)+(E2))). Because of the conversion rules that apply to the binary + operator, if E1 is an array object (equivalently, a pointer to the initial element of an array object) and E2 is an integer, E1 [E2] designates the E2-th element of E1 (counting from zero).

ISO/IEC 9899:2011, Information technology -- Programming languages -- C

再谈一维数组

【数组名相当于指向数组第一个元素的指针】

若 a 是 指向数组第一个元素 的指针,即a相当于&a[0];

- ◆ &a是 "指向数组"的指针; &a+1将跨越16个字节;
 - ●&a 相当于 管辖范围 "上升" 了一级;
- ◆*a 是数组的第一个元素a[0];即*a等价于a[0];
 - ●*a 相当于 管辖范围 "下降" 了一级;

$$a \longrightarrow a[0] \ a[1] \ a[2] \ a[3]$$
 $a+1 \ a+2 \ a+3 \ a+4$

本节内容

- ■字符串与指针
- ■指向二维数组的指针
 - ◆ 再谈一维数组的地址
 - ◆ 指向二维数组的指针
 - ◆ 利用指针遍历二维数组

再谈一维数组

【数组名相当于指向数组第一个元素的指针】

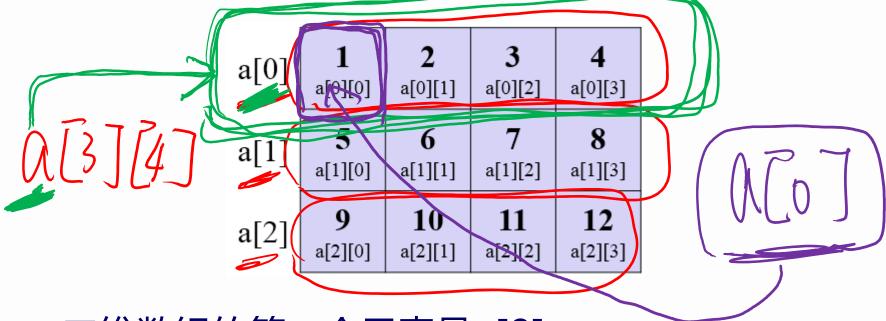
若 a 是 指向数组第一个元素 的指针,即a相当于&a[0];

- ◆ &a是 "指向数组"的指针; &a+1将跨越16个字节;
 - &a 相当于 管辖范围 "上升" 了一级;
- ◆*a 是数组的第一个元素a[0];即*a等价于a[0];
 - ●*a 相当于 管辖范围 "下降" 了一级;

$$a \longrightarrow a[0] \ a[1] \ a[2] \ a[3]$$
 $a+1 \ a+2 \ a+3 \ a+4$

二维数组 也一样!

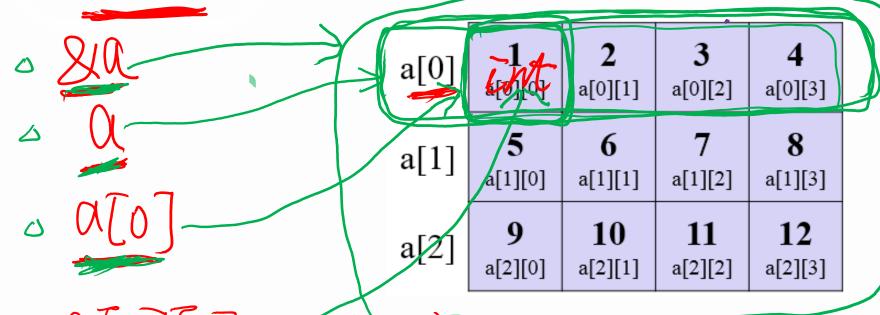
- 二维数组的定义
 - ◆二维数组a[3][4]包含三个元素:a[0], a[1], a[2]
 - ●每个元素都是一个"包含四个整型元素"的数组



- ◆ 二维数组的第一个元素是a[0]
- ◆ a[0]是一个"包含四个整型元素"的一维数组;

二维数组 也一样!

int $a[3][4] = \{\{1,2,3,4\}, \{5,6,7,8\}, \{9,10,11,12\}\};$



- ◆ a与&a[0]等价;
- ◆ a[0]与&a[0][0]等价;
- ◆ a[0]与*a等价;
- ◆ a[0][0]与**a等价;

小结

三条规律

- +数组名相当于指向数组第一个元素的指针;
- ◆ 冬 E 相当于把 E的管辖范围上升了一个级别
- ◆*E 相当于把E的管辖范围下降了一个级别

```
int main()
   int a[3][4]=\{\{1,2,3,4\}, \{5,6,7,8\}, \{9,10,11,12\}\};
   cout<<'' a = ''<<a<<endl;
   cout << " &a[0] = " << &a[0] << endl << endl;
                                                               0列
                                                                    1列
                                                                          2列
                                                                               3列
   cout << " a+1 = " << a+1 << endl;
                                                                                4
   cout << " &a[0]+1 = " << &a[0]+1 << endl << endl; off
                                                              a[0][0]
                                                                   a[0][1]
                                                                         a[0][2]
                                                                              a[0][3]
                                                                               8
   cout<<" *a = "<<*a<<endl;
                                                           1行
                                                              a[1][0]
                                                                   a[1][1] a[1][2]
                                                                              a[1][3]
   cout << '' a[0] = '' << a[0] << endl;
                                                               9
                                                                    10
                                                                          11
                                                                               12
   cout << " &a[0][0] = " << &a[0][0] << endl << endl;
                                                              a[2][0]
                                                                   a[2][1]
                                                                         a[2][2]
                                                                              a[2][3]
   cout<<" *a+1 = "<<*a+1<<endl;
   cout << '' a[0]+1 = '' << a[0]+1 << endl;
   cout << ''&a[0][0]+1 = ''<<&a[0][0]+1<< endl<< endl;
   return 0;
```

```
int main()
  int a[3][4] = \{\{1,2,3,4\}, \{5,6,7,8\}, \{9,10,11,12\}\};
                                                        a = 0x0013FF50
  cout<<" a = "<<a<endl;
                                                   &a[0] = 0x0013FF50
  cout << " &a[0] = " << &a[0] << endl << endl;
                                                     a+1 = 0x0013FF60
  cout << " a+1 = " << a+1 << endl;
                                                 &a[0]+1 = 0x0013FF60
  cout << " &a[0]+1 = " << &a[0]+1 << endl << e
  cout<<" *a = "<<*a<<endl;
                                                      *a = 0x0013FF50
  cout << " a[0] = " << a[0] << endl;
                                                    a[0] = 0x0013FF50
                                                &a[0][0] = 0x0013FF50
  cout << " &a[0][0] = " << &a[0][0] << endl << e1
  cout<<" *a+1 = "<<*a+1<<endl;
                                                    *a+1 = 0x0013FF54
  cout << " a[0]+1 = " << a[0]+1 << endl;
                                                  a[0]+1 = 0x0013FF54
  cout << ``&a[0][0]+1 = `'<<&a[0][0]+1 << endl &a[0][0]+1 = 0x0013FF54
  return 0;
                                              Press any key to continue
```

```
#include<iostream.h>
void main()
  int a[3][4]=\{\{1,2,3,4\}, \{5,6,7,8\}, \{9,10,11,12\}\};
   cout<<" a = "<<a<<endl;
   cout << " &a[0] = " << &a[0] << endl << endl;
   cout << " a+1 = " << a+1 << endl;
   cout << " &a[0]+1 = " << &a[0]+1 << endl << endl;
                                                                       2列
                                                                            3列
                                                             0列
                                                                  1列
   cout << " a[1] = " << a[1] << endl;
                                                                        3
                                                                  2
                                                                             4
                                                        0行
   cout<<" &a[1] = "<<&a[1]<<endl;
                                                                 a[0][1]
                                                                      a[0][2]
                                                                            a[0][3]
                                                            a[0][0]
   cout << " *(a+1) = " << *(a+1) << endl << endl;
                                                        1行
                                                            a[1][0]
                                                                 a[1][1]
                                                                      a[1][2]
                                                                            a[1][3]
   cout<<" *a+1 = "<<*a+1<<endl<
                                                             9
                                                                  10
                                                                       11
                                                                            12
                                                        2行
                                                            a[2][0]
                                                                 a[2][1]
                                                                      a[2][2]
                                                                            a[2][3]
   cout<<" &a = "<<&a<<endl;
   cout << '' &a+1 = '' << &a+1 << endl;
```

```
#include<iostream.h>
void main()
  int a[3][4]=\{\{1,2,3,4\}, \{5,6,7,8\}, \{9,10,11,12\}\};
  cout<<" a = "<<a<<endl;
                                                        a = 0x0013FF50
  cout << " &a[0] = " << &a[0] << endl << endl;
                                                   &a[0] = 0x0013FF50
  cout << " a+1 = " << a+1 << endl;
                                                     a+1 = 0x0013FF60
  cout << " &a[0]+1 = " << &a[0]+1 << endl << endl; &a[0]+1 = 0x0013FF60
  cout << " a[1] = " << a[1] << endl;
                                                    a | 1 | = 0 \times 0013 FF 60
  cout<<" &a[1] = "<<&a[1]<<endl;
                                                   &a[1] = 0x0013FF60
  cout << " *(a+1) = " << *(a+1) << endl << endl;
                                                  *(a+1) = 0x0013FF60
  cout<<" *a+1 = "<<*a+1<<endl<
                                                    *a+1 = 0x0013FF54
  cout<<" &a = "<<&a<<endl;
                                                      \&a = 0x0013FF50
  cout<<" &a+1 = "<<&a+1<<endl;
                                                    &a+1 = 0x0013FF80
```

小结

【数组名相当于指向数组第一个元素的指针】

- ◆*a 等价于a[0],相当于让a下降了一级;
- ◆ &a 表示"指向二维数组"的指针,相当于上升了一级;

int $a[3][4] = \{\{1,3,5,7\}, \{9,11,13,15\}, \{17,19,21,23\}\};$

	0列	1列	2列	3列
0行	1 a[0][0]	2 a[0][1]	3 a[0][2]	4 a[0][3]
1行	5 a[1][0]	6 a[1][1]	7 a[1][2]	8 a[1][3]
2行	9 a[2][0]	10 a[2][1]	11 a[2][2]	12 a[2][3]

本节内容

- ■字符串与指针
- ■指向二维数组的指针
 - ◆ 再谈一维数组的地址
 - ◆ 指向二维数组的指针
 - ◆ 利用指针遍历二维数组

遍历数组元素

```
#include<iostream>
                                        0x0013FF50
using namespace std;
                                        0x0013FF54 3
int main()
                                        0x001/3FF58 5
                                        0x0013FF5C 🔏
  int a[3][4] = \{1, 3, 5, 7, 9, 11, 13, 15, 17,
                                        0x0013FF60
  19, 21, 23};
                                        0x0013FF64 11
  int *p;
                                        0x0013FF68 13
          (0) p \times &a[0][0]+12, p++)
                                        0x0013FF6C 15
                                        0x0013FF70 17
      cout<<p<<" " " << *p << endl;
                                        0x0013FF74 19
                                        0x0013FF78 21
  return 0;
                                        0x0013FF7C 23
```

二维数组

int a[3][4];

	0列	1列	2列	3列
0行	1 a[0][0]	2 a[0][1]	3 a[0][2]	a[0][3]
1行	5	6	7	8
2行	a[1][0] 9	a[1][1] 10	a[1][2] -	12
211	a[2][0]	a[2][1]	a[2][2]	a[2][3]

•••		
a[0][0]		
a[0][1]		
a[0][2]		
a[0][3]		
a[1][0]		
a[1][1]		
a[1][2]		
a[1][3]		
a[2][0]		
a[2][1]		
a[2][2]		
a[2][3]		
(1	
V		
•••		

程序填空&判断正误

```
■ 输入 i, j; 输出a[i][j];
int main()
  int a[3][4]=\{1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23\};
 int _____, i, j; // 填空: 完成变量p的定义
  p = a;
  cin>>i>>j; // i<3 代表行号, j<4代表列号
  cout<<setw(4)<<*(*(p+i)+j); //正误判断: 访问元素a[i][j]
  return 0;
```

问题分析

- 从 **p** = **a** 开始
 - ◆ a 相当于指向a[3][4]的"第一个元素"的指针;
 - ◆ 所谓"第一个元素"是指一个"包含4个int型元素的一维数组";
 - ◆ 所以,a相当于一个"包含4个int型元素的一维数组"的地址;
 - ◆ 因此, p的基类型应该是:
 - "包含4个int型元素的一维数组"

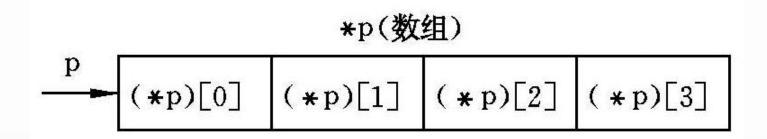
利用指针变量引用多维数组中的数组

■问题

◆ 如何定义一个指向"包含4个int型元素的一维数组"的指针变量?

■ 解答

◆ 变量定义语句: int (*p)[4];



程序填空&判断正误

```
■ 输入 i, j; 输出a[i][j];
int main()
  int a[3][4]=\{1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23\};
  int (*p)[4], i, j; // 填空:完成变量p的定义
  p = a;
  cin>>i>>j;
                  // i<3 代表行号, j<4代表列号
  cout<<setw(4)<<*(*(p+i)+j); //正误判断: 访问元素a[i][j]
  return 0;
```

利用指针变量引用多维数组中的数组

- *(*(p+i)+j) 是什么?
 - ◆p指向一个"包含4个int型元素的一维数组";
 - ◆p+i是第i+1个"包含4个int型元素的一维数组"的地址。
 - ◆p+i等价于 &a[i];
 - ◆*(p + i) 等价于a[i];
 - ◆*(p+i)+j等价于 a[i]+j
 - ◆因为: a[i] + j 等价于 &a[i][j]
 - ◆ *(*(p+i)+j) 等价于 a[i][j]

利用指针变量引用多维数组中的数组

```
■ 输入 i, j; 输出a[i][j];
main()
  int a[3][4]=\{1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23\};
  int (*p)[4], i, j;
  p = a;
  cin>>i>>j;
  cout<<setw(4)<<p[i][j];
```



谢 谢!

