**Mutation Operator for Triangle Example**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Mutation Category** | **ID** | **Mutation Type** | **Examples** | | |
| **No.** | **Original** | **Replaced** |
| **Triangle** | | | | | |
| Arithmetic Operations | 1 | Arithmetic Operator Replacement | ① | c < a + b | c < a - b |
| ② | a < b + c | a < b - c |
| ③ | b < a + c | b < a - c |
| 2 | Arithmetic Operator Insertion | ① | a < b + c | a < -b + c |
| ② | c < a + b | -c < a + b |
| ③ | b == c | b == -c |
| ④ | a == b | a == -b |
| Relations | 3 | Relational Operator Replacement | ① | a != b | a == b |
| ② | b == c | b != c |
| ③ | b != c | b == c |
| Conditions | 4 | Conditional Operator Replacement | ① | (a==b)&&(b==c) | (a==b)||(b==c) |
| Constants | 5 | Constant Value Modification | ① | s = 3 | s = 4 |
| ② | s = 1 | s = 0 |
| ③ | s = 2 | s = 3 |
| Return Values | 6 | Return Value Modification | ① | return s | return 0 |
| ② | return s | Return 2 |

**Mutation Operator for Next Date Example**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mutation Category | ID | Mutation Type | Examples | | |
| No. | Original | Replaced |
| Arithmetic Operations | 1 | Arithmetic Operator Replacement | ① | mdy[1] = d + 1 | mdy[1] = d - 1 |
| ② | mdy[0] = m + 1 | mdy[0] = m - 1 |
| ③ | mdy[2] = y + 1 | mdy[2] = y - 1 |
| 2 | Arithmetic Operator Insertion | ① | m == 3 | m == -3 |
| ② | m == 11 | m == -11 |
| ③ | d < 31 | d < -31 |
| ④ | d < 28 | d < -28 |
| ⑤ | mdy[1] = d + 1 | mdy[1] = -d + 1 |
| ⑥ | mdy[0] = m + 1 | Mdy[0] = -m + 1 |
| Relations | 3 | Relational Operator Replacement | ① | m == 5 | m !=5 |
| ② | m == 9 | m != 9 |
| ③ | d < 30 | D == 30 |
| ④ | d < 28 | d > 28 |
| Conditions | 4 | Conditional Operator Replacement | ① | (m==3)||(m==5) | (m==3)&&(m==5) |
| ② | (m==9)||(m==11) | (m==9)&&(m==11) |
| ③ | y % 4 == 0 && y % 100 != 0 | y % 4 == 0 || y % 100 != 0 |
| Constants | 5 | Constant Value Modification | ① | mdy[1] = 1 | mdy[1] = 2 |
| ② | mdy[0] = 1 | mdy[0] = 5 |

**Mutation Operator for Vending Machine Example**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Mutation Category** | **ID** | **Mutation Type** | **Examples** | | |
| **No.** | **Original** | **Replaced** |
| **Triangle** | | | | | |
| Arithmetic Operations | 2 | Arithmetic Operator Insertion | ① | 7. else if(orangeJuice == 0 && beer == 1){ | 7. else if(orangeJuice == 0 && beer == -1){ |
| ② | 17. else if(fiftyCents == 1 && oneDollar == 0){ | 17. else if(fiftyCents == -1 && oneDollar == 0){ |
| ③ | 73. if(orangeJuice == 1 && beer == 1){ | 73. if(orangeJuice == -1 && beer == 1){ |
| Relations | 3 | Relational Operator Replacement | ① | 10. else if(orangeJuice == 0 && beer == 0){ | 10. else if(orangeJuice != 0 && beer == 0){ |
| ② | 21. else if(orangeJuice == 0 && beer == 1){ | 21. else if(orangeJuice == 0 && beer != 1){ |
| ③ | 59. if(orangeJuice == 1 && beer == 0){ | 59. if(orangeJuice != 1 && beer == 0){ |
| ④ | 72. else if(oneDollar == 0 && fiftyCents == 0){ | 72. else if(oneDollar == 0 && fiftyCents != 0){ |
| Conditions | 4 | Conditional Operator Replacement | ① | 4. if(orangeJuice == 1 && beer == 0){ | 4. if(orangeJuice == 1 || beer == 0){ |
| ② | 17. else if(fiftyCents == 1 && oneDollar == 0){ | 17. else if(fiftyCents == 1 || oneDollar == 0){ |
| ③ | 48. else if(orangeJuice == 0 && beer == 1){ | 48. else if(orangeJuice == 0 || beer == 1){ |
| ④ | 73. if(orangeJuice == 1 && beer == 1){ | 73. if(orangeJuice == 1 || beer == 1){ |
| Return Values | 6 | Return Value Modification | ① | 8. return 2; | 8. return 5; |
| ② | 25. return 3; | 25. return 4; |
| ③ | 40. return 10; | 40. return 7; |
| ④ | 77. return 7; | 77. return 1; |