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Minesweeper Game Implementation Report

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Introduction
This project involves implementing a Minesweeper game with configurable grid size and mine count. The objective is to reveal all cells that do not contain mines. This report details the implementation, functionalities, and design decisions of the Minesweeper game.

Game Mechanics

Cell Interaction
- Only unrevealed cells are clickable.
- Left-clicking a cell reveals it, showing either a mine, a number indicating neighboring mines, or an empty cell.
- Right-clicking toggles a flag on unrevealed cells.

Cell Display
- Revealed cells show the number of adjacent mines or are empty if no mines are nearby.
- Empty cells reveal neighboring cells recursively.

Restart
- A restart button starts a new game with a different mine layout.

Score
- A score label displays the number of revealed cells.

Hints
- A hint button suggests an unrevealed, safe cell.

End Game
Losing Condition
- Left-clicking a mine results in a game over.

Winning Condition
- Revealing all non-mine cells results in a win.

Post-Game
- All mines are revealed upon winning or losing, with a notification popup.
- The restart button remains clickable after the game ends.
- All cells are unclickable until a new game starts.

Hints

Hint Mechanism
- The hint button suggests an unrevealed cell guaranteed not to contain a mine.
- If no safe move exists, no hint is provided.
- Hints are based on visible information to the player.

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Implementation

Code Structure
Classes
- **Cell**: Represents individual cells, inheriting from `QPushButton`. Handles right-click events to toggle flags.
- **Minesweeper**: Manages the game grid, cell states, game logic, and UI components.

```
class Cell : public QPushButton {
   Q_OBJECT

public:
   explicit Cell(QWidget *parent = nullptr);

signals:
   void rightClicked();

protected:
   void mousePressEvent(QMouseEvent *event) override;
};

Cell::Cell(QWidget *parent) : QPushButton(parent) {}

void Cell::mousePressEvent(QMouseEvent *event) {
   if (event->button() == Qt::RightButton) {
      emit rightClicked();
   } else {
      QPushButton::mousePressEvent(event);
   }
}
```

Constructor
- Initializes the grid, cell states, and UI components. Configurable rows, columns, and mine count.

```
Minesweeper::Minesweeper(int rows, int columns, int mines, QWidget *parent)
   : QWidget(parent), score(0), hintRow(-1), hintCol(-1), hintGiven(false), rows(rows),
columns(columns), mines(mines) {
   grid.resize(rows, std::vector<int>(columns, 0));
   revealed.resize(rows, std::vector<bool>(columns, false));
   flagged.resize(rows, std::vector<bool>(columns, false));

   srand(time(nullptr));
   placeMines();

   QVBoxLayout *mainLayout = new QVBoxLayout(this);
```

```
    scoreLabel = new QLabel("Score: 0", this);
    mainLayout->addWidget(scoreLabel);

    QHBoxLayout *topLayout = new QHBoxLayout();
    restartButton = new QPushButton("Restart", this);
    hintButton = new QPushButton("Hint", this);

    connect(restartButton, &QPushButton::clicked, this, &Minesweeper::handleRestartClick);
    connect(hintButton, &QPushButton::clicked, this, &Minesweeper::handleHintClick);

    topLayout->addWidget(restartButton);
    topLayout->addWidget(hintButton);
    mainLayout->addLayout(topLayout);

    gridLayout = new QGridLayout();
    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < columns; ++j) {
            Cell *button = new Cell(this);
            button->setFixedSize(30, 30);
            button->setProperty("row", i);
            button->setProperty("col", j);
            connect(button, &QPushButton::clicked, this, [=]() {
                int row = button->property("row").toInt();
                int col = button->property("col").toInt();
                handleButtonClick(row, col);
            });
            connect(button, &Cell::rightClicked, this, [=]() {
                int row = button->property("row").toInt();
                int col = button->property("col").toInt();
                handleRightClick(row, col);
            });
            gridLayout->addWidget(button, i, j);
        }
    }
    mainLayout->addLayout(gridLayout);
    setLayout(mainLayout);
}
```

- placeMines:
- Randomly places mines in the grid.

```
void Minesweeper::placeMines() {
    int count = 0;
    while (count < mines) {
        int row = rand() % rows;
        int col = rand() % columns;
        if (grid[row][col] != 9) {
            grid[row][col] = 9;
            ++count;
        }
    }
}
```

- countAdjacentMines:
  - Counts mines adjacent to a given cell.

```
int Minesweeper::countAdjacentMines(int row, int col) {
    int count = 0;
    for (int i = -1; i <= 1; ++i) {
        for (int j = -1; j <= 1; ++j) {
            int newRow = row + i;
            int newCol = col + j;
            if (newRow >= 0 && newRow < rows && newCol >= 0 && newCol < columns &&
grid[newRow][newCol] == 9) {
                ++count;
            }
        }
    }
    return count;
}
```

- revealCell:
  - Reveals a cell and recursively reveals empty neighbors.

```
void Minesweeper::revealCell(int row, int col) {
    if (revealed[row][col]) {
        return;
    }
    revealed[row][col] = true;
    ++score;
    scoreLabel->setText("Score: " + QString::number(score));
    Cell *button = qobject_cast<Cell *>(gridLayout->itemAtPosition(row, col)->widget());
    button->setEnabled(false);

    // Set shadow color for revealed button
    button->setStyleSheet("background-color: #d3d3d3; color: #000000;");

    int adjacentMines = countAdjacentMines(row, col);
    if (adjacentMines > 0) {
        button->setText(QString::number(adjacentMines));
    } else {
        for (int i = -1; i <= 1; ++i) {
            for (int j = -1; j <= 1; ++j) {
                int newRow = row + i;
                int newCol = col + j;
                if (newRow >= 0 && newRow < rows && newCol >= 0 && newCol < columns) {
                    revealCell(newRow, newCol);
                }
            }
        }
    }
}
```

- gameOver:

- Handles the game-over state by revealing all mines and displaying a notification.

```
void Minesweeper::gameOver() {
    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < columns; ++j) {
            if (grid[i][j] == 9) {
                Cell *button = qobject_cast<Cell *>(gridLayout->itemAtPosition(i, j)->widget());
                button->setText("*");
            }
        }
    }
    QMessageBox::information(this, "Game Over", "You hit a mine!");
    resetGame();
}
```

- checkWin:

- Checks if all non-mine cells are revealed to determine a win.

```
void Minesweeper::checkWin() {
    bool win = true;
    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < columns; ++j) {
            if (!revealed[i][j] && grid[i][j] != 9) {
                win = false;
                break;
            }
        }
    }
    if (win) {
        QMessageBox::information(this, "Congratulations", "You won the game!");
        resetGame();
    }
}
```

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- resetGame:
- Resets the game state for a new round.

```
void Minesweeper::resetGame() {
    score = 0;
    scoreLabel->setText("Score: 0");
    grid = std::vector<std::vector<int>>(rows, std::vector<int>(columns, 0));
    revealed = std::vector<std::vector<bool>>(rows, std::vector<bool>(columns, false));
    flagged = std::vector<std::vector<bool>>(rows

, std::vector<bool>(columns, false));
    hintRow = -1;
    hintCol = -1;
    hintGiven = false;
    placeMines();

    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < columns; ++j) {
            Cell *button = qobject_cast<Cell *>(gridLayout->itemAtPosition(i, j)->widget());
            button->setEnabled(true);
            button->setText("");
            button->setStyleSheet(""); // Reset style
        }
    }
}
```

- isSafeCell:
- Determines if a cell is safe to reveal based on adjacent revealed cells.

```
bool Minesweeper::isSafeCell(int row, int col) {
    if (revealed[row][col] || grid[row][col] == 9) {
        return false;
    }

    // Check adjacent revealed cells
    for (int i = -1; i <= 1; ++i) {
        for (int j = -1; j <= 1; ++j) {
            int newRow = row + i;
            int newCol = col + j;
            if (newRow >= 0 && newRow < rows && newCol >= 0 && newCol < columns &&
revealed[newRow][newCol]) {
                return true;
            }
        }
    }
    return false;
}
```

- findSafeCell:
  - Finds a safe cell for the hint mechanism.

```
std::pair<int, int> Minesweeper::findSafeCell() {
    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < columns; ++j) {
            if (isSafeCell(i, j)) {
                return {i, j};
            }
        }
    }
    return {-1, -1};
}
```

- giveHint:
  - Provides a hint by highlighting a safe cell or revealing it if already suggested.

```
void Minesweeper::giveHint() {
    if (hintGiven && hintRow != -1 && hintCol != -1 && !revealed[hintRow][hintCol]) {
        revealCell(hintRow, hintCol);
        checkWin();
        hintRow = -1;
        hintCol = -1;
        hintGiven = false;
    } else {
        auto [row, col] = findSafeCell();
        if (row != -1 && col != -1) {
            hintRow = row;
            hintCol = col;
            hintGiven = true;
            Cell *button = qobject_cast<Cell *>(gridLayout->itemAtPosition(row, col)->widget());
            button->setStyleSheet("background-color: #90EE90; ");
        } else {
            hintGiven = false;
        }
    }
}
```

- handleButtonClick:
  - Handles left-click events on cells.

```
void Minesweeper::handleButtonClick(int row, int col) {
    if (hintGiven && row == hintRow && col == hintCol) {
        hintRow = -1;
        hintCol = -1;
        hintGiven = false;
    }
    if (grid[row][col] == 9) {
        gameOver();
    } else {
        revealCell(row, col);
        checkWin();
    }
}
```

- handleRestartClick:
  - Handles the restart button click to reset the game.

```
void Minesweeper::handleRestartClick() {
    resetGame();
}
```

- handleHintClick:
  - Handles the hint button click to provide a hint.

```
void Minesweeper::handleHintClick() {
    giveHint();
}
```

- handleRightClick:
  - Handles right-click events on cells to toggle flags.

```
void Minesweeper::handleRightClick(int row, int col) {
    if (flagged[row][col]) {
        flagged[row][col] = false;
        Cell *button = qobject_cast<Cell *>(gridLayout->itemAtPosition(row, col)->widget());
        button->setText("");
    } else {
        flagged[row][col] = true;
        Cell *button = qobject_cast<Cell *>(gridLayout->itemAtPosition(row, col)->widget());
        button->setText("F");
    }
}
```

- Main Function:
  - Starts the application and initializes the Minesweeper game.

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```
int main(int argc, char *argv[]) {
    QApplication app(argc, argv);
    Minesweeper minesweeper(10, 10, 10); // Default grid size 10x10 with 10 mines
    minesweeper.setWindowTitle("Minesweeper");
    minesweeper.show();
    return app.exec();
}

#include "main.moc"
```

Challenges and Solutions
- Recursive Revealing:
  - Managed stack overflow risks by limiting recursion depth and ensuring proper base case checks.
- Hint Accuracy:
  - Ensured hints only suggested cells based on visible information to maintain game integrity.

Usage
- Running the Game:
  - Compile and run the `main.cpp` file.
  - The game starts with a default 10x10 grid and 10 mines.
- Controls:
  - Left-click to reveal cells.
  - Right-click to toggle flags.
  - Use the restart button to start a new game.
  - Use the hint button for safe cell suggestions.

Conclusion
This Minesweeper implementation meets the project requirements, including configurable grid size, mine count, and hint functionality. The game mechanics and end conditions are faithfully recreated, providing an engaging and challenging gameplay experience. The implementation is modular and extensible, allowing for easy modifications and enhancements.