Database CRUD Operations in Python

In this tutorial you will learn how to perform CRUD operations in Python with the SQLite database. Python has built-in support for SQLite in the form of the sqlite3 module. This module contains functions for performing persistent CRUD operations on SQLite database.

Sqlite Database

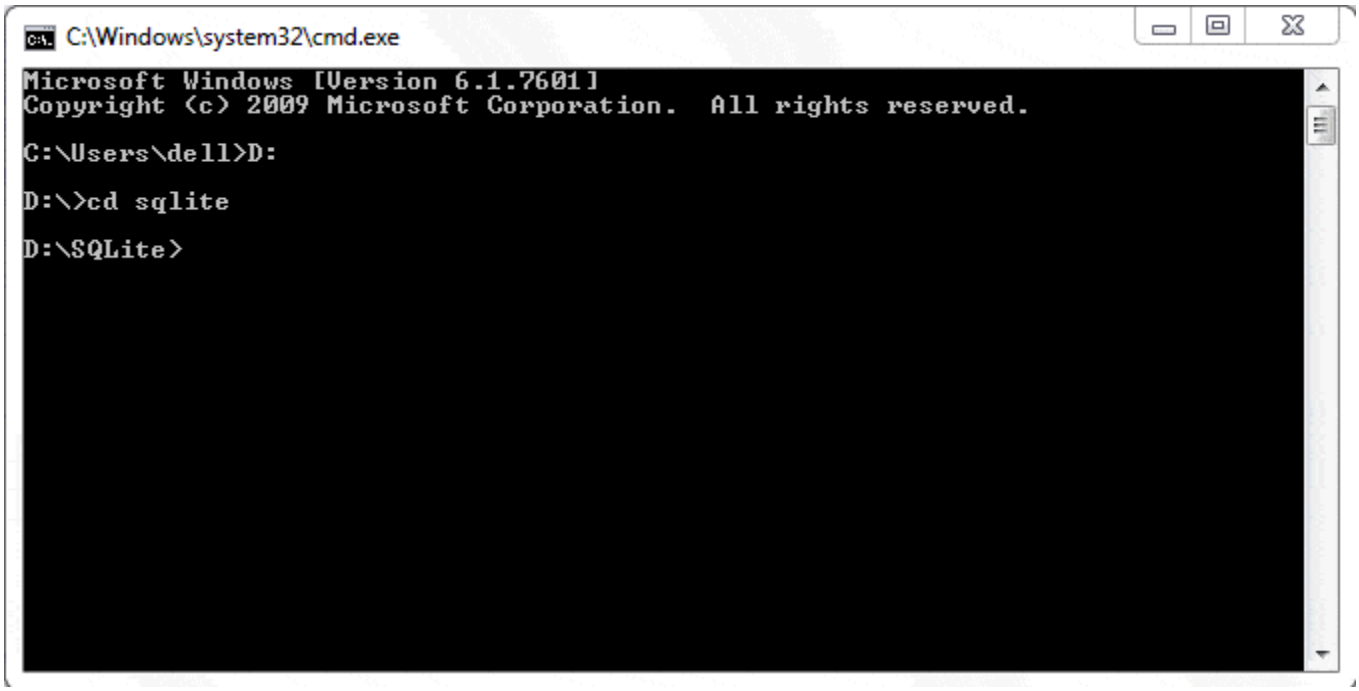
SQLite is a self-contained transactional relational database engine that doesn't require a server configuration, as in the case of Oracle, MySQL, etc. It is an open source and in-process library developed by D. Richard Hipp in August 2000. The entire SQLite database is contained in a single file, which can be put anywhere in the computer's file system.

SQLite is widely used as an embedded database in mobile devices, web browsers and other stand-alone applications. In spite of being small in size, it is a fully ACID compliant database conforming to ANSI SQL standards.

SQLite is freely downloadable from the official web site https://www.sqlite.org/download.html. This page contains pre-compiled binaries for all major operating systems. A bundle of command-line tools contain command-line shell and other utilities to manage SQLite database files.

We shall download the latest version of SQLite (version 3.25.1) along with command-line tools and extract the archive.

To create a new SQLite database, navigate from the command prompt to the folder where you have unzipped the archive and enter the following command:



Sqlite3 Command

It is now possible to execute any SQL query. The following statement creates a new table. (Ensure that the statement ends with a semicolon)

```
sqlite> create table student(name text, age int, marks real);
```

Add a record in the above table.

```
sqlite> insert into student values('Ramesh', 21, 55.50);
```

To retrieve the record, use the SELECT query as below:

```
sqlite> select * from student;
Ramesh|21|55.5
```

Python DB-API

Python Database API is a set of standards recommended by a Special Interest Group for database module standardization. Python modules that provide database interfacing functionality with all major database products are required to adhere to this standard. DB-API standards were further modified to DB-API 2.0 by another Python Enhancement proposal (PEP-249).

Standard Python distribution has in-built support for SQLite database connectivity. It contains sqlite3 module which adheres to DB-API 2.0 and is written by Gerhard Haring. Other RDBMS products also have DB-API compliant modules:

- MySQL: PyMySql module
- Oracle: Cx-Oracle module
- SQL Server: PyMsSql module
- PostGreSQL: psycopg2 module
- ODBC: pyodbc module

As per the prescribed standards, the first step in the process is to obtain the connection to the object representing the database. In order to establish a connection with a SQLite database, sqlite3 module needs to be imported and the `connect()` function needs to be executed.

```
>>> import sqlite3
>>> db=sqlite3.connect('test.db')
```

The `connect()` function returns a connection object referring to the existing database or a new database if it doesn't exist.

The following methods are defined in the connection class:

Method	Description
cursor()	Returns a Cursor object which uses this Connection.
commit()	Explicitly commits any pending transactions to the databse. The method should be a no-op if the underlying db does not support transactions.
rollback()	This optional method causes a transaction to be rolled back to the starting point. It may not be implemented everywhere.
close()	Closes the connection to the database permanently. Attempts to use the connection after calling this method will raise a DB-API Error.

A cursor is a Python object that enables you to work with the database. It acts as a handle for a given SQL query; it allows the retrieval of one or more rows of the result. Hence, a cursor object is obtained from the connection to execute SQL queries using the following statement:

```
>>> cur=db.cursor()
```

The following methods of the cursor object are useful.

Method	Description
execute()	Executes the SQL query in a string parameter
executemany()	Executes the SQL query using a set of parameters in the list of tuples
fetchone()	Fetches the next row from the query result set.
fetchall()	Fetches all remaining rows from the query result set.
callproc()	Calls a stored procedure.
close()	Closes the cursor object.

The `commit()` and `rollback()` methods of the connection class ensure transaction control. The `execute()` method of the cursor receives a string containing the SQL query. A string having an incorrect SQL query raises an exception, which should be properly handled. That's why the `execute()` method is placed within the try block and the effect of the SQL query is persistently saved using the `commit()` method. If however, the SQL query fails, the resulting exception is processed by the except block and the pending transaction is undone using the `rollback()` method.

Typical use of the `execute()` method is as follows:

Example:
```
try:
    cur=db.cursor()
    cur.execute("Query")
    db.commit()
    print ("success message")
except:
    print ("error")
    db.rollback()
db.close()
```

Create a New Table

A string enclosing the CREATE TABLE query is passed as parameter to the `execute()` method of the cursor object. The following code creates the student table in the test.db database.

Example: Create a New Table in Sqlite
```
import sqlite3
db=sqlite3.connect('test.db')
try:
    cur =db.cursor()
    cur.execute('''CREATE TABLE student (
    StudentID INTEGER PRIMARY KEY AUTOINCREMENT,
    name TEXT (20) NOT NULL,
    age INTEGER,
    marks REAL);''')
    print ('table created successfully')
except:
    print ('error in operation')
    db.rollback()
db.close()
```

This can be verified using the `.tables` command in sqlite shell.

```
E:\SQLite>sqlite3 test.db
SQLite version 3.25.1 2018-09-18 20:20:44
Enter ".help" for usage hints.
sqlite> .tables
student
```

Insert a Record

Once again, the `execute()` method of the cursor object should be called with a string argument representing the INSERT query syntax. We have created a student table having three fields: name, age and marks. The string holding the INSERT query is defined as:

```
qry="INSERT INTO student (name, age, marks) VALUES
('Rajeev',20,50);"
```

We have to use it as a parameter to the `execute()` method. To account for possible exceptions, the `execute()` statement is placed in the try block as explained earlier. The complete code for the inset operation is as follows:

Example: Insert a Record in Sqlite

```
import sqlite3
db=sqlite3.connect('test.db')
qry="insert into student (name, age, marks) values('Rajeev', 20, 50);"
try:
    cur=db.cursor()
    cur.execute(qry)
    db.commit()
    print ("one record added successfully")
except:
    print ("error in operation")
    db.rollback()
db.close()
```

You can check the result by using the SELECT query in Sqlite shell.

```
sqlite> select * from student;
1|Rajeev|20|50.0
```

Using Parameters in a Query

Often, the values of Python variables need to be used in SQL operations. One way is to use Python's string `format()` function to put Python data in a string. However, this may lead to SQL injection attacks to your program. Instead, use parameter substitution as recommended in Python DB-API. The ? character is used as a placeholder in the query string and provides the values in the form of a tuple in the `execute()` method. The following example inserts a record using the parameter substitution method:

Example:

```
import sqlite3
db=sqlite3.connect('test.db')
qry="insert into student (name, age, marks) values(?,?,?);"
try:
    cur=db.cursor()
    cur.execute(qry, ('Vijaya', 16,75))
    db.commit()
```

```
    print ("one record added successfully")
except:
    print("error in operation")
    db.rollback()
db.close()
```

The `executemany()` method is used to add multiple records at once. Data to be added should be given in a list of tuples, with each tuple containing one record. The list object (containing tuples) is the parameter of the `executemany()` method, along with the query string.

Example:

```
import sqlite3
db=sqlite3.connect('test.db')
qry="insert into student (name, age, marks) values(?,?,?);"
students=[('Amar', 18, 70), ('Deepak', 25, 87)]
try:
    cur=db.cursor()
    cur.executemany(qry, students)
    db.commit()
    print ("records added successfully")
except:
    print ("error in operation")
    db.rollback()
db.close()
```

Retrieve Records

When the query string holds a SELECT query, the `execute()` method forms a result set object containing the records returned. Python DB-API defines two methods to fetch the records:

1. fetchone(): Fetches the next available record from the result set. It is a tuple consisting of values of each column of the fetched record.
2. fetchall(): Fetches all remaining records in the form of a list of tuples. Each tuple corresponds to one record and contains values of each column in the table.

When using the `fetchone()` method, use a loop to iterate through the result set, as below:

Example: Fetch Records

```
import sqlite3
db=sqlite3.connect('test.db')
sql="SELECT * from student;"
cur=db.cursor()
cur.execute(sql)
while True:
    record=cur.fetchone()
    if record==None:
        break
    print (record)
db.close()
```

When executed, the following output is displayed in the Python shell:

Result:

```
(1, 'Rajeev', 20, 50.0)
(2, 'Vijaya', 16, 75.0)
(3, 'Amar', 18, 70.0)
(4, 'Deepak', 25, 87.0)
```

The `fetchall()` method returns a list of tuples, each being one record.

Example:

```
students=cur.fetchall()
for rec in students:
print (rec)
```

Update a Record

The query string in the `execute()` method should contain an UPDATE query syntax. To update the value of 'age' to 17 for 'Amar', define the string as below:

```
qry="update student set age=17 where name='Amar';"
```

You can also use the substitution technique to pass the parameter to the UPDATE query.

Example: Update Record

```
import sqlite3
db=sqlite3.connect('test.db')
qry="update student set age=? where name=?;"
try:
    cur=db.cursor()
    cur.execute(qry, (19,'Deepak'))
    db.commit()
    print("record updated successfully")
except:
    print("error in operation")
    db.rollback()
db.close()
```

Delete a Record

The query string should contain the DELETE query syntax. For example, the below code is used to delete 'Bill' from the student table.

```
qry="DELETE from student where name='Bill';"
```

You can use the ? character for parameter substitution.

Example: Delete Record

```
import sqlite3
db=sqlite3.connect('test.db')
```

```
qry="DELETE from student where name=?;"
try:
    cur=db.cursor()
    cur.execute(qry, ('Bill',))
    db.commit()
    print("record deleted successfully")
except:
    print("error in operation")
    db.rollback()
db.close()
```