

GUI PROGRAM FOR CALENDAR FORMULAS

BERNDT E. SCHWERDTFEGER

ABSTRACT. This paper describes my implementation of the *Julian* day function in a GUI program using Qt.

PREFACE

Earlier this year (June 2010) I published the command line program `cal` [2] that implements the *Julian* day number j introduced by *John Herschel* in 1849. In this paper I describe my implementation with a graphical user interface (GUI), making use of the open source software Qt (pronounced *cute*).

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1. JULIAN DAY NUMBER, JULIAN AND GREGORIAN DATES

Julian dates proper describe all calendar dates since the calendar reform of *Julius Caesar*, valid as of Friday -44-1-1 (in modern ISO 8601 notation) until Thursday 1582-10-4. The dates October 5-14 in 1582 have been dismissed by the *Gregorian* calendar reform and the dates continued with Friday 1582-10-15.

We will assume so called *proleptic* dates: as if the *Julian* numbering of years had been in use ever since until 1582, and as if the *Gregorian* numbering will be used forever since 1582. This infinite set has to be limited somehow for practical purposes; I have chosen the *year* range from -9,999,999 to +9,999,999.

The *Julian* day number to be used in Astronomy was proposed in 1849 by astronomer *John Herschel*, based on the *Julian period* suggested by *Joseph Scaliger* in 1583. This number denotes the number of days passed since -4712-1-1. The formula expressing *Julian* day number $j(y, m, d)$ in terms of calendar dates y - m - d is given in my article *On calendar formulas* [2]. Some values are

$$\begin{array}{ll} j(-4712, 1, 1) = 0 & j(1, 1, 1) = 1,721,424 \\ j(1582, 10, 4) = 2,299,160 & j(1582, 10, 15) = 2,299,161 \\ j(2001, 1, 1) = 2,451,911 & j(2010, 12, 24) = 2,455,555 \end{array}$$

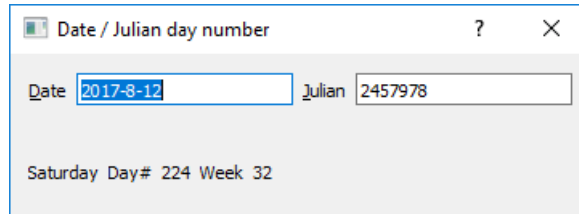
2. THE GUI VERSION OF THE CALENDAR PROGRAM

2.1. **GUI and main program.** The user interface is straightforward with two data entry fields *date* and *julian* day number, switching between them is done by the *Tab* key. Starting with a *date* the *julian* day number will be displayed and vice versa.

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The weekday, the day of the year and the week of the year is shown as well. A regular expression validator checks for meaningful entry data. The validator allows for the 29th of February and the program corrects it silently to March 1st in non-leap years. The dismissed dates from the *Gregorian* calendar reform are *invalid*. The user interface is described in the appendix A.3.



The calendar formulas are identical to those in [2]. As I make use of the open source software Qt [1], the program structure is completely different and will only look familiar if you are used to Qt programming. The main program is the standard trivial Qt application, the dialog logic hidden in the class `CalgDialog`: //

```

/* -----
Module:   main.cpp, 2011-04-05
          Calendar formulas, GUI version
-----

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limitations under the License.
-----*/

#include <QApplication>
#include "calgdialog.h"

// -----
// main function
// -----

int main(int argc, char* argv[]){

    QApplication app(argc, argv);
    CalgDialog* dialog = new CalgDialog;
    dialog->show();
    return app.exec();
}
//

```

2.2. Date validator. The regular expression used in the validator for allowed dates looks complicated

```

[+|-]?[0-9]{1,7}-(((0?[1-9]|1[0-2])-(0?[1-9]|[1-2]\\d))\
|((0?[13-9]|1[0-2])-(30|((0?[13578]|1[02])-(31))

```

so let us look at the details.

The first part is clear

```
[+|-]?[0-9]{1,7}-
```

all years in the range $-9,999,999$ to $+9,999,999$ are allowed. The *plus*-sign $+$ is optional. After the year a *dash*-sign $-$ is obligatory.

The next part

```
((0?[1-9]|1[0-2])-(0?[1-9]|1[1-2]\\d))
```

describes $mm-dd$ with month values $01 \leq mm \leq 12$ and day values $01 \leq dd \leq 29$, with leading 0 maybe omitted.

The last two parts

```
((0?[13-9]|1[0-2])-30)|((0?[13578]|1[02])-31))
```

add the 30th of all months except for February and the 31st for the months 1, 3, 5, 7, 8, 10, 12.

REFERENCES

- [1] Jasmin Blanchette and Mark Summerfield, *C++ GUI Programming with Qt 4*, 2nd ed., Prentice Hall, 2008.
- [2] Berndt E. Schwerdtfeger, *On calendar formulas* (2010), available at <http://berndt-schwerdtfeger.de/wp-content/uploads/pdf/calj.pdf>.

APPENDIX A. PROGRAM LISTINGS OF CALGDIALOG

This appendix gathers the program listings for `calgdiallog` of

- the implementation of class `CalgDialog`
- the header file `calgdiallog.h`
- the user interface `calgdiallog.ui`

A.1. Implementation of class `CalgDialog`. The class `CalgDialog` implements the complete program logic, including the input validator and the user interface. The input fields emit a `editingFinished` signal in case the validator returns `Acceptable` and line editing loses focus (*Tab* key).

The signals trigger the corresponding slots: `slot on_dateEdit_editingFinished` for *date* resp. `slot on_julianEdit_editingFinished` for *julian* day number. The processing in both slots is similar (and some optimization should be done - lazy me!), more or less stolen from `cal.c`, so I do not need to explain the details.

The other functions `date`, `leap` and `quot` are well-known by now. //

```
/* -----
Module:  calgdiallog.cpp, 2011-04-05
        dialog part for calendar GUI program
-----*/
```

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```

-----*/

#include <QWidget>
#include "calgdialog.h"
int em[13] = {0,0,31,59,90,120,151,181,212,243,273,304,334};
QString weekdays = "Monday Tuesday Wednesday Thursday Friday Saturday Sunday";
QStringList wday = weekdays.split(" ");

// -----
CalgDialog::CalgDialog(QWidget* parent) : QDialog(parent) {

    setupUi(this);
    QRegExp datefmt("[+|-]?[0-9]{1,7}-(((0?[1-9]|1[0-2])-(0?[1-9]|[1-2]\\d))\\
|((0?[13-9]|1[0-2])-(30)|((0?[13578]|1[02])-(31))))");
    dateEdit->setValidator(new QRegExpValidator(datefmt, this));
    QRegExp julianfmt("[+|-]?[0-9]{1,10}");
    julianEdit->setValidator(new QRegExpValidator(julianfmt, this));

// connect(quitButton, SIGNAL(clicked()), this, SLOT(reject()));

}

// -----
void CalgDialog::on_dateEdit_editingFinished() {

    ErrMsg->setText(" "); // clear error message
    QString text = dateEdit->text(); // pull out the string
    QStringList datelist = text.split("-",QString::SkipEmptyParts);
    long long y = datelist[0].toLongLong(); // set year
    if (text.left(1) == "-") y=-y; // correct if negative
    int m = datelist[1].toInt(); // set month
    int d = datelist[2].toInt(); // set day
    long long j = 0; // julian

// the following code comes from cal.c

    if (y==1582 && m==10 && d>4 && d<15) {
        ErrMsg->setText("Date invalid!");
        Week->setText(" ");
        Day->setText(" ");
        weekday->setText(" ");
        julianEdit->setText(" ");
        return;
    }
}

```

```

}
if (y < 1582 || (y == 1582 && m*100+d < 1005)) // Julian era
    j = 1721423 + d + em[m] + (y-1)*365 + quot(y-1,4);
else { // Gregorian era
    long long x = y - 2001;
    j = 2451910 + d + em[m] + x*365 + quot(x,4) - quot(x,100) + quot(x,400);
}
if (m>2) j+=leap(y); // correction for leap year
if (j < 2299161) { // Julian era
    y=1582;
    date(j-2298883,&y,&m,&d); // calculate the date
}
else { // Gregorian era
    y=1583;
    date(j-2299238,&y,&m,&d); // calculate the date
}
int n = d + em[m]; // offset into this year
if (m > 2)
    n += leap(y); // adjust for leap day
if (y==1582 && n>278) n-=10; // ten days dropped in 1582
int w = j%7; // set weekday
if (w<0) w+=7;

datelist[0]=QString::number(y);
datelist[1]=QString::number(m);
datelist[2]=QString::number(d);
text = datelist.join("-");
dateEdit->setText(text);
julianEdit->setText(QString::number(j));
Week->setText(QString::number((n-w+9)/7));
Day->setNum(n);
weekday->setText(wday[w]);
}

// -----
void CalgDialog::on_julianEdit_editingFinished() {
    QString text = julianEdit->text(); // pull out the string
    long long j = text.toLongLong();
    long long y = 0;
    int m,d;
    if (j < 2299161) { // Julian era
        y=1582;
        date(j-2298883,&y,&m,&d); // calculate the date
    }
    else { // Gregorian era
        y=1583;
        date(j-2299238,&y,&m,&d); // calculate the date
    }
    int n = d + em[m]; // offset into this year
    if (m > 2)
        n += leap(y); // adjust for leap day
    if (y==1582 && n>278) n-=10; // ten days dropped in 1582
}

```

```

int w = j%7; // set weekday
if (w<0) w+=7;

QStringList datelist;
datelist << QString::number(y) << QString::number(m) << QString::number(d);
text = datelist.join("-");
dateEdit->setText(text);
julianEdit->setText(QString::number(j));
Week->setText(QString::number((n-w+9)/7));
Day->setNum(n);
weekday->setText(wday[w]);
}

// -----
void CalgDialog::date(long long n, long long* y, int* m, int* d){

    int i;
    while (n > 365 + leap(*y)){ // if offset larger than # of
        n -= 365 + leap(*y); // ... days in a year
        *y += 1; // ... find the correct year
    }
    while (n <= 0){ // if offset is negative
        *y -= 1; // ... find the correct year
        n += 365 + leap(*y); // ... and offset
    }
    i = leap(*y); // adjust for leap day
    *m = 12;
    while (n <= em[*m] + i){ // searching for the month
        *m -= 1;
        if (*m<3) i=0;
    }
    *d = n - em[*m] - i; // setting the day
}

// -----
int CalgDialog::leap(long long y){

    int i = 0;
    if (y%4 == 0)
        i = 1;
    if (y > 1582 && y%100 == 0 && y%400 != 0)
        i = 0;
    return i;
}

// -----
long long CalgDialog::quot(long long a, long long b){

    long long x = a/b;
    if (a < 0 ) // for negative numerator ..
        x -= (a%b != 0); // .. if remainder, subtract 1
    return x;
}

```

```
}

```

```
//

```

A.2. **Header file** calgdialog.h. The header file contains the declarations and includes the user interface header ui_calgdialog.h, which is automatically compiled by the user interface compiler at build time of the project. //

```
/* -----
Module:  calgdialog.h, 2011-04-05
        header file for calendar GUI program
-----*/

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limitations under the License.

-----*/
#ifndef CALGDIALOG_H
#define CALGDIALOG_H

#include <QDialog>
#include "ui_calgdialog.h"

class CalgDialog : public QDialog, public Ui::CalgDialog
{
    Q_OBJECT

public:
    CalgDialog(QWidget* parent=0);

private slots:
    void on_dateEdit_editingFinished();
    void on_julianEdit_editingFinished();

private:
    void date(long long, long long*, int*, int*);
    long long quot(long long, long long); // = [a/b] (corrected: works if a < 0)
    int leap(long long); // = 1 if year is a leap year
};
#endif
//

```

A.3. **User Interface file** calgdialog.ui. The user interface (the GUI form) was designed with Qt Designer, which stores its information in an XML file, the user interface file calgdialog.ui. The user interface compiler uic then compiles the header file ui_calgdialog.h, which I have not included.

```
<?xml version="1.0" encoding="UTF-8"?>
<ui version="4.0">
  <class>CalgDialog</class>
  <widget class="QWidget" name="CalgDialog">
    <property name="geometry">
      <rect>
        <x>0</x>
        <y>0</y>
        <width>360</width>
        <height>100</height>
      </rect>
    </property>
    <property name="windowTitle">
      <string>Date / Julian day number</string>
    </property>
    <widget class="QWidget" name="">
      <property name="geometry">
        <rect>
          <x>11</x>
          <y>12</y>
          <width>339</width>
          <height>71</height>
        </rect>
      </property>
      <layout class="QVBoxLayout" name="verticalLayout">
        <item>
          <layout class="QHBoxLayout" name="horizontalLayout">
            <item>
              <widget class="QLabel" name="dateLabel">
                <property name="text">
                  <string>&Date</string>
                </property>
                <property name="indent">
                  <number>1</number>
                </property>
                <property name="buddy">
                  <cstring>dateEdit</cstring>
                </property>
              </widget>
            </item>
            <item>
              <widget class="QLineEdit" name="dateEdit">
                <property name="whatsThis">
                  <string>enter date in format year-mm-dd</string>
                </property>
              </widget>
            </item>
          </layout>
        </item>
      </layout>
    </widget>
  </property>
</ui>
```



```

<widget class="QLabel" name="julianLabel">
  <property name="text">
    <string>&Julian</string>
  </property>
  <property name="buddy">
    <cstring>julianEdit</cstring>
  </property>
</widget>
</item>
<item>
  <widget class="QLineEdit" name="julianEdit">
    <property name="whatsThis">
      <string>julian day number</string>
    </property>
  </widget>
</item>
</layout>
</item>
<item>
  <widget class="QLabel" name="ErrMsg">
    <property name="enabled">
      <bool>>true</bool>
    </property>
    <property name="whatsThis">
      <string>error message</string>
    </property>
    <property name="text">
      <string/>
    </property>
    <property name="indent">
      <number>0</number>
    </property>
  </widget>
</item>
<item>
  <layout class="QHBoxLayout" name="horizontalLayout_2">
    <item>
      <widget class="QLabel" name="weekday">
        <property name="whatsThis">
          <string>weekday</string>
        </property>
        <property name="text">
          <string>Wednesday</string>
        </property>
        <property name="indent">
          <number>0</number>
        </property>
      </widget>
    </item>
    <item>
      <widget class="QLabel" name="dayLabel">
        <property name="text">

```

```

        <string>Day#</string>
    </property>
</widget>
</item>
<item>
    <widget class="QLabel" name="Day">
        <property name="whatsThis">
            <string>day number of the year</string>
        </property>
        <property name="text">
            <string>000</string>
        </property>
    </widget>
</item>
<item>
    <widget class="QLabel" name="weekLabel">
        <property name="text">
            <string>Week</string>
        </property>
    </widget>
</item>
<item>
    <widget class="QLabel" name="Week">
        <property name="whatsThis">
            <string>week number of the year</string>
        </property>
        <property name="text">
            <string>00</string>
        </property>
    </widget>
</item>
<item>
    <spacer name="horizontalSpacer">
        <property name="orientation">
            <enum>Qt::Horizontal</enum>
        </property>
        <property name="sizeHint" stdset="0">
            <size>
                <width>40</width>
                <height>20</height>
            </size>
        </property>
    </spacer>
</item>
</layout>
</item>
</layout>
</widget>
</widget>
<tabstops>
    <tabstop>dateEdit</tabstop>
    <tabstop>julianEdit</tabstop>

```

```
</tabstops>  
<resources/>  
<connections/>  
</ui>
```

A.4. **Remarks for make.** After installing Qt5 in October 2013 I noticed that several classes have been moved from *QtGui* to the new module *QtWidgets*. Therefore, the project file has to be adapted.

Here are the steps:

- create a directory `calg` and put the project files into it
- create the project file `calg.pro`: `qmake -project`
- edit the project file and add the string `QT += widgets`
- create the makefiles and subdirs (debug, release): `qmake`
- make the executable: `make release`