μTalk

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pdfsplit

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A bit of Lua code, the `\clip` macro and leptonica extensions are the ingredients for this recipe to cook a `pdfsplit` macro that take a pdf and try to split into parts as the `\vsplit` does with `\vboxes`.

1 Slice a pdf

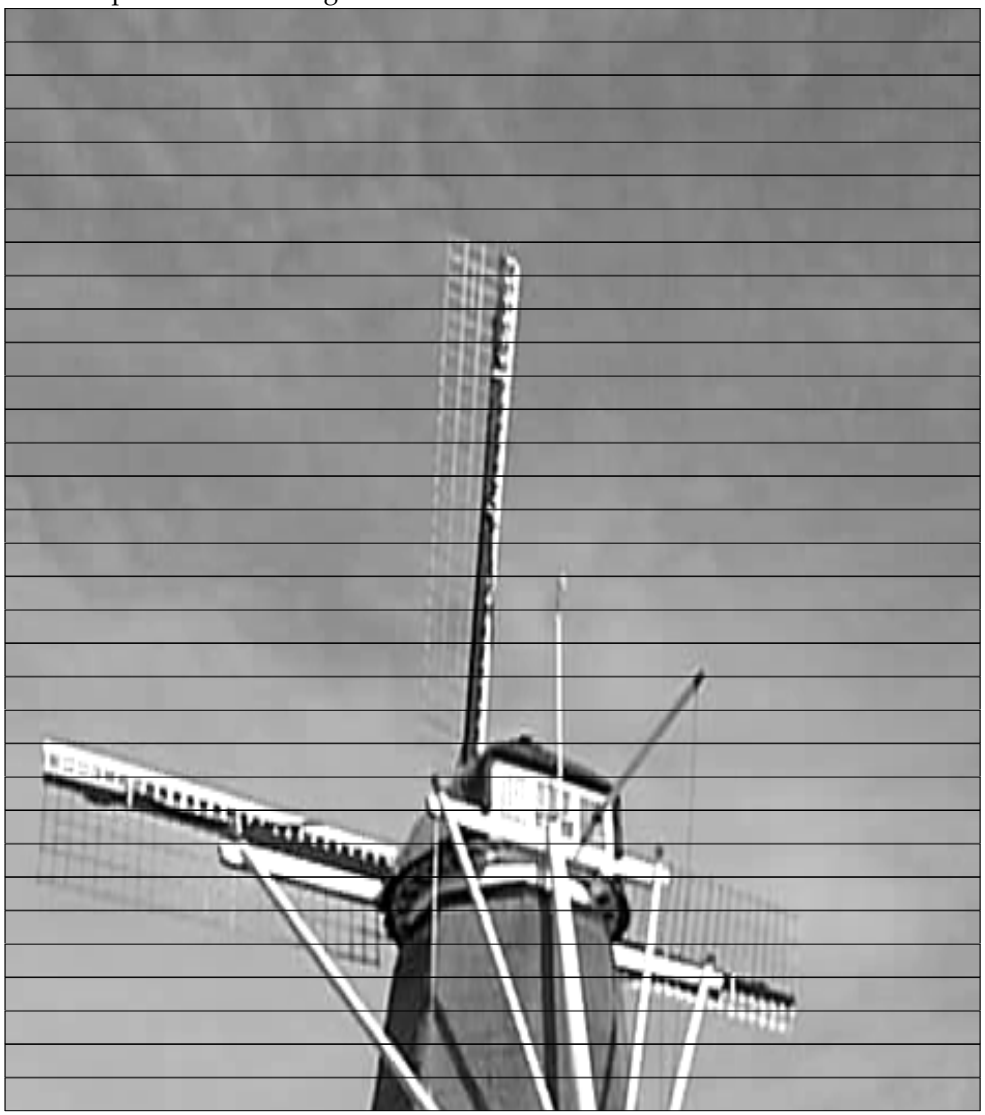
Let's start with a bit of Lua code:

```
\startluacode
document.lscarso = document.lscarso or {}
function document.lscarso.LuaSliceIt(Fig,H,W,L,FigOpt)
 local H =  math.floor(string.gsub(H,"pt","")*2^16)
 local W =  math.floor(string.gsub(W,"pt","")*2^16)
 local L =  math.floor(string.gsub(L,"pt","")*2^16)
 local vh = 0
 local step = L
 local h = step
 local S = ""
 local FigOpt = FigOpt or ""
 while vh <= H do
   S =string.format("{\\clip[voffset=\%dsp,
                             width=\%dsp,
                             height=\%dsp]
                            {\\externalfigure[\%s][\%s]}}
                            \\par\\nointerlineskip\\blank[1sp]",
                            vh,W,h,Fig,FigOpt)
   tex.sprint(tex.ctxcatcodes,S)
   vh = vh + step
 end
 if math.mod(H,step) > 0 then
      vh = vh - step + math.mod(H,step)
      S =string.format("{\\clip[voffset=\%dsp,
                             width=\%dsp,
                             height=\%dsp]
                            {\\externalfigure[\%s][\%s]}}
                            \\par\\nointerlineskip\\blank[1sp]",
                            vh,W,math.mod(H,step),Fig,FigOpt)
      tex.sprint(tex.ctxcatcodes,S)
 end
end
\stopluacode
```

`document.lscarso.LuaSliceIt` takes a pdf and "slices it" with slices of height `L`.

```
\bgroup
\newdimen\Hfig \newdimen\Wfig
\setbox1000=\hbox{\externalfigure[mill.png][width=\textwidth,
                                            height=1.3\textheight]}
\Wfig=\wd1000 \Hfig=\dimexpr\ht1000+\dp1000\relax%
\ctxlua{document.lscarso.LuaSliceIt("mill.png","\the\Hfig",
                        "\the\Wfig","\the\dimexpr 1.0\lineheight\relax",
                        "width=\\textwidth,height=1.3\\textheight")}
\egroup
```

It's not a problem with images:



But uniform slicing is wrong with text:

$$\sum_{x=0}^{10} \frac{1}{x+1} = \frac{83711}{27720} = 3.019877344877344877344877345$$

$$\sum_{x=0}^{100} \frac{1}{x+1} = \frac{14639190792407439662689546747109297683610 83}{28167031592803840774471658809866170636947 2} = 5.19727850773863016179521668 6$$

$$\sum_{x=0}^{150} \frac{1}{x+1} = \frac{41955696676761358111539698151370732349445617467329193399143372019 27}{74950290119682722826682048179211899329291912740854280826732942400 0} = 5.59780310520017018796571597 3$$

$$4\sum_{x=0}^{30} \frac{-1^x}{2x+1} = \frac{58630135791001973169852284}{18472920064106597929865025} = 3.17384233719074940869022414 0$$

$$4\sum_{x=0}^{300} \frac{-1^x}{2x+1} = 3.14491490355885179920458621 2$$

$$4\sum_{x=0}^{3000} \frac{-1^x}{2x+1} = 3.14192587583979015127120007 5$$

$$4\sum_{x=0}^{30000} \frac{-1^x}{2x+1} = 3.14162598581204323815399369 2$$

$$4\sum_{x=0}^{300000} \frac{-1^x}{2x+1} = 3.14159598691201548846261251 9$$

$$4\sum_{x=0}^{3000000}\frac{-1^x}{2x+1} = 3.14159298692301546071264338$$

We can enumerate each slice, and observe that it depends only on the given `step`: with `step = 1.0\lineheight` we have

001 $$\sum_{x=0}^{10}\frac{1}{x+1} = \frac{83711}{27720} = 3.019877344877344877344877345$$

002

003 $$\sum_{x=0}^{100}\frac{1}{x+1} = \frac{14639190792407439662689546747109297683610 83}{28167031592803840774471658809866170636947 2} = 5.19727850773863016179521668 6$$

004

005 $$\sum_{x=0}^{150}\frac{1}{x+1} = \frac{41955696676761358111539698151370732349445617467329193399143372019 27}{74950290119682722826682048179211899329291912740854280826732942400 0} = 5.59780310520017018796571597 3$$

006

007 $$4\sum_{x=0}^{30}\frac{-1^x}{2x+1} = \frac{58630135791001973169852284}{18472920064106597929865025} = 3.17384233719074940869022414 0$$

008

009 $$4\sum_{x=0}^{300}\frac{-1^x}{2x+1} = 3.14491490355885179920458621 2$$

010

011 $$4\sum_{x=0}^{3000}\frac{-1^x}{2x+1} = 3.14192587503979015127120007 5$$

012

013 $$4\sum_{x=0}^{30000}\frac{-1^x}{2x+1} = 3.14162598581204323815399369 2$$

014

015 $$4\sum_{x=0}^{300000}\frac{-1^x}{2x+1} = 3.14159598691201548846261251 9$$

016

017 $$4\sum_{x=0}^{3000000}\frac{-1^x}{2x+1} = 3.14159298692301546071264338 0$$

018

019

020

It's now clear that 002, 004, 006... are good break points while 001, 003, 005... must be avoided:. if we collect all good break points we can then subdivide the pdf into the right `\vboxes`. These break points depend on `lineheight`, but we can choose another `step`, let's say `2mm`, so that slices are independent from the body font:

```
\bgroup
\newdimen\Hfig \newdimen\Wfig
\setbox1000=\hbox{\externalfigure[pari_example.pdf][width=\textwidth]}
\Wfig=\wd1000 \Hfig=\dimexpr\ht1000+\dp1000\relax%
\ctxlua{document.lscarso.LuaSliceItNR("pari_example.pdf","\the\Hfig",
                        "\the\Wfig","\the\dimexpr 2mm\relax",
                        "width=\\textwidth")}
\egroup
```

001

002 $$\sum_{x=0}^{10}\frac{1}{x+1} = \frac{83711}{27720} = 3.019877344877344877344877345$$

003

004

005

006

007 $$\sum_{x=0}^{100}\frac{1}{x+1} = \frac{14639190792407439662689546747109297683610 83}{28167031592803840774471658809866170636947 2} = 5.19727850773863016179521668 6$$

008

009

010

$$\sum_{x=0}^{150} \frac{1}{x+1} = \frac{4195569667676135811153969815137073234944561746732919339914337201927}{749502901196827228266820481792118993292919127408542808267329424000} = 5.597803105200170187965715973$$

$$4\sum_{x=0}^{30} \frac{-1^x}{2x+1} = \frac{5863013579100197316985228 4}{184729200641065979298650 25} = 3.173842337190749408690224140$$

$$4\sum_{x=0}^{300} \frac{-1^x}{2x+1} = 3.144914903558851799204586212$$

$$4\sum_{x=0}^{3000} \frac{-1^x}{2x+1} = 3.141925875839790151271200075$$

$$4\sum_{x=0}^{30000} \frac{-1^x}{2x+1} = 3.141625985812043238153993692$$

$$4\sum_{x=0}^{300000} \frac{-1^x}{2x+1} = 3.141595986912015488462612519$$

$$4\sum_{x=0}^{3000000} \frac{-1^x}{2x+1} = 3.141592986923015460712643380$$

We group together slices `1,5,9,13,14,18,22,26,31,35,39`:

$$\sum_{x=0}^{10} \frac{1}{x+1} = \frac{83711}{27720} = 3.019877344877344877344877345$$

$$\sum_{x=0}^{100} \frac{1}{x+1} = \frac{14639190792407439662689546747109297683610 83}{28167031592803840774471658809866170636947 2} = 5.197278507738630161795216686$$

$$\sum_{x=0}^{150} \frac{1}{x+1} = \frac{4195569667676135811153969815137073234944561746732919339914337201927}{749502901196827228266820481792118993292919127408542808267329424000} = 5.597803105200170187965715973$$

$$4\sum_{x=0}^{30} \frac{-1^x}{2x+1} = \frac{5863013579100197316985228 4}{184729200641065979298650 25} = 3.173842337190749408690224140$$

$$4\sum_{x=0}^{300} \frac{-1^x}{2x+1} = 3.144914903558851799204586212$$

$$4\sum_{x=0}^{3000} \frac{-1^x}{2x+1} = 3.141925875839790151271200075$$

$$4\sum_{x=0}^{30000} \frac{-1^x}{2x+1} = 3.141625985812043238153993692$$

$$4\sum_{x=0}^{300000} \frac{-1^x}{2x+1} = 3.141595986912015488462612519$$

$$4\sum_{x=0}^{3000000} \frac{-1^x}{2x+1} = 3.141592986923015460712643380$$

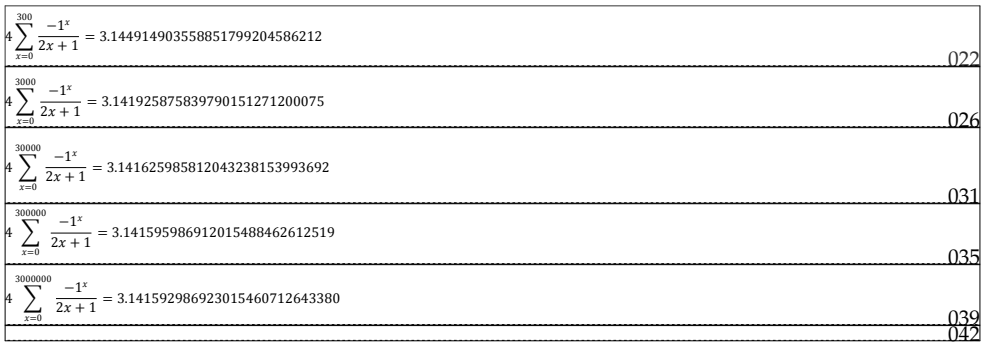
Now slicing works well:

$$\sum_{x=0}^{10} \frac{1}{x+1} = \frac{83711}{27720} = 3.019877344877344877344877345$$

$$\sum_{x=0}^{100} \frac{1}{x+1} = \frac{14639190792407439662689546747109297683610 83}{28167031592803840774471658809866170636947 2} = 5.197278507738630161795216686$$

$$\sum_{x=0}^{150} \frac{1}{x+1} = \frac{4195569667676135811153969815137073234944561746732919339914337201927}{749502901196827228266820481792118993292919127408542808267329424000} = 5.597803105200170187965715973$$

$$4\sum_{x=0}^{30} \frac{-1^x}{2x+1} = \frac{5863013579100197316985228 4}{184729200641065979298650 25} = 3.173842337190749408690224140$$




```
\bgroup
\newdimen\Hfig \newdimen\Wfig
\setbox1000=\hbox{\externalfigure[pari_example.pdf][width=\textwidth]}
\Wfig=\wd1000 \Hfig=\dimexpr\ht1000+\dp1000\relax%
\startluacode
 document.lscarso.GoodPoints = {1,5,9,13,14,18,22,26,31,35,39}
\stopluacode
\ctxlua{document.lscarso.LuaSliceItAndCollect("pari_example.pdf",
                "\the\Hfig","\the\Wfig","\the\dimexpr 2mm\relax",
                "width=\\textwidth","")}
\egroup

function document.lscarso.LuaSliceItAndCollect(Fig,H,W,L,FigOpt)
 local H =  math.floor(string.gsub(H,"pt","")*2^16)
 local W =  math.floor(string.gsub(W,"pt","")*2^16)
 local L =  math.floor(string.gsub(L,"pt","")*2^16)
 local vh = 0
 local step = L
 local h = step
 local S = ""
 local FigOpt = FigOpt or ""
 local NR = 0
 local Payload = "{\\ruledhbox{\\clip[voffset=\%dsp,width=\%dsp,height=\%dsp]
{\\externalfigure[\%s][\%s]}\\llap{\\tfx\%03d}}}
\\par\\nointerlineskip\\blank[1sp]"
 local GoodPoint = document.lscarso.GoodPoints or {}
 local j = 1
 local Vboxes = {}
 local prevvh = 0
 while vh < H do
   NR =NR +1
   vh = vh + step
   if GoodPoint[j] == NR then
      Vboxes[#Vboxes+1] = {from=prevvh,to=vh,mark=NR}
      --tex.sprint(tex.ctxcatcodes,"(",prevvh,",",vh,") ")
```

```
      prevvh = vh
      j = j +1
    end
  end
  if math.mod(H,step) == 0 then H = H +1  end
  if math.mod(H,step) > 0 then
    NR = NR +1
    vh = vh - step + math.mod(H,step)
    Vboxes[#Vboxes+1] = {from=prevvh,to=vh,mark=NR}
  end
  Payload = "\\ruledvbox{\\hbox{\\clip[voffset=\%dsp,width=\%dsp,height=\%dsp]
{\\externalfigure[\%s][\%s]}\\llap{\\tfx\%03d}}}
\\par\\nointerlineskip\\blank[1sp]"
  for i,v in ipairs(Vboxes) do
     S =string.format(Payload,v.from,W,v.to-v.from,Fig,FigOpt,v.mark)
     tex.sprint(tex.ctxcatcodes,S)
  end
```

It's now rather trivial to modify this macro to build a `\vbox` to be used with `\vsplit`.

2 Leptonica

Leptonica (`http:\\www.leptonica.com`) is a pedagogically-oriented open source site containing software that is useful for image processing and image analysis applications. It's not difficult to build a binding for Lua with SWIG. To use Leptonica we must first convert the pdf in a black and white bitmap with

```
pdftoppm -mono -r 72 -f 1 -l 1 pari_example.pdf pari_example
```

(this saves page 1 in `pari_example-000001.pbm` with a resolution of 72dpi). Then we scan the bitmap with `lept_get_breaks` searching for a white row and we store the y coordinates in `GoodPoints`. In the end `LuaCollect` builds the appropriate `vboxes`.

```
\bgroup
\newdimen\Hfig \newdimen\Wfig
\setbox1000=\hbox{\externalfigure[pari_example.pdf][width=\textwidth]}
\Wfig=\wd1000\relax\Hfig=\dimexpr\ht1000+\dp1000\relax%
\executesystemcommand{pdftoppm -mono -r 72 -f 1 -l 1 pari_example.pdf
pari_example}
\ctxlua{document.lscarso.GoodPoints =
           document.lscarso.lept_get_breaks("pari_example-000001.pbm",72)}
\ctxlua{document.lscarso.LuaCollect("pari_example.pdf",
                        "\the\Hfig","\the\Wfig",[[width=\textwidth]])}
\egroup
```

Let's see what happens:

$$\sum_{x=0}^{10} \frac{1}{x+1} = \frac{83711}{27720} = 3.019877344877344877344877345$$

$$\sum_{x=0}^{100} \frac{1}{x+1} = \frac{14639190792407439662689546747109297683610 83}{28167031592803840774471658809866170636947 2} = 5.197278507738630161795216686$$

$$\sum_{x=0}^{150} \frac{1}{x+1} = \frac{41955696676761358111539698151370732349445617467329193399143372019 27}{74950290119682722826682048179211899329291912740854280826732942400 0} = 5.597803105200170187965715973$$

$$4\sum_{x=0}^{30} \frac{-1^x}{2x+1} = \frac{58630135791001973169852284}{18472920064106597929865025} = 3.173842337190749408690224140$$

$$4\sum_{x=0}^{300} \frac{-1^x}{2x+1} = 3.144914903558851799204586212$$

$$4\sum_{x=0}^{3000} \frac{-1^x}{2x+1} = 3.141925875839790151271200075$$

$$4\sum_{x=0}^{30000} \frac{-1^x}{2x+1} = 3.141625985812043238153993692$$

$$4\sum_{x=0}^{300000} \frac{-1^x}{2x+1} = 3.141595986912015488462612519$$

$$4\sum_{x=0}^{3000000} \frac{-1^x}{2x+1} = 3.141592986923015460712643380$$

A good breakpoint is marked with an horizontal rule: a black stripe means that good points are very tight there.

```
require("leptonica")
function document.lscarso.lua_pixGetPixel(pixs,x,y)
    local scratch = 0
    local res = ''
    scratch = leptonica.uti_getref_l_uint32()
    if (leptonica.pixGetPixel(pixs,x,y,scratch) == 0) then
       res =  leptonica.uti_valref_l_uint32(scratch)
    else
     print("! Error on ",x,y)
     res = ''
    end
    return res
end

function document.lscarso.lept_get_breaks(filename,res)
     -- os.execute([[pdftoppm -mono filename]])
     local mainName = filename
     local pixs = leptonica.pixRead(mainName)
     local lua_pixGetPixel = document.lscarso.lua_pixGetPixel
     local GoodPoint = {}  -- document.lscarso.GoodPoints or {}
     if pixs then
        local w =  leptonica.pixGetWidth(pixs)
        local h =  leptonica.pixGetHeight(pixs)
        local d =  leptonica.pixGetDepth(pixs)
        local out = ''
        local bit
        local storey = true
        local go
        GoodPoint[1] = 0
        for y=0,h-1 do
           out = ''
           storey = true
           for x=0,w-1 do
              bit =  lua_pixGetPixel(pixs,x,y)
              if bit == 1 then
                storey = false
                break
              end
           end
           if storey and (math.floor(0.5+ (y/res) *72.27*2^16)
              ~= GoodPoint[#GoodPoint]) then
```

```
                GoodPoint[#GoodPoint +1] = math.floor(0.5+ (y/res)
*72.27*2^16)
           end
           storey = true
        end
        GoodPoint[#GoodPoint +1] = math.floor(0.5+ (h/res) *72.27*2^16)
      else
       tex.sprint("ERROR")
      end
      return GoodPoint
end


function document.lscarso.LuaCollect(Fig,H,W,FigOpt)
 local H =  math.floor(string.gsub(H,"pt","")*2^16)
 local W =  math.floor(string.gsub(W,"pt","")*2^16)
 local vh = 0
 local h = step
 local S = ""
 local FigOpt = FigOpt or ""
 local NR = 0
 local Payload = ""
 local GoodPoint = document.lscarso.GoodPoints or {}
 local j = 1
 local Vboxes = {}
 local prevvh = 0
 local truey =  GoodPoint[#GoodPoint]
 local y_ratio = H / truey
 for i,v in ipairs(GoodPoint) do
     if GoodPoint[i+1] == nil then
        break
     end
     NR = NR +1
     Vboxes[#Vboxes+1] = {from=v,to=GoodPoint[i+1],mark=NR}
 end
 Payload = "\\ruledvbox{\\hbox{\\clip[voffset=\%dsp,width=\%dsp,height=\%dsp]
           {\\externalfigure[\%s][\%s]}}}\\par\\nointerlineskip\\blank[1sp]"
 for i,v in ipairs(Vboxes) do
    S =string.format(Payload,y_ratio*v.from,W,y_ratio*(v.to-v.from),Fig,FigOpt)
    tex.sprint(tex.ctxcatcodes,S)
 end
end
```

3 MuPDF

We can replace the `pdftoppm` call by building a Lua binding to MuPDF, "a lightweight PDF viewer and toolkit written in portable C" (`http:\\www.mupdf.com`). Sumatra (`http://en.wikipedia.org/wiki/Sumatra_PDF`) is a fast pdfviewer based on MuPDF.

Despite MuPDF is a well written library and there are several examples that explain how to use it, it's not easy to write a converter.
What follow is only a part of an almost literal translation into Lua of the C program `pdfdraw.c` and even so the debugging is difficult.

```
function drawpbm(pagenum)
   local xref = pdfdraw.targetpdf.xref
   local drawrotate = pdfdraw.drawrotate
   local drawzoom   = pdfdraw.drawzoom
   local drawbands  = pdfdraw.drawbands
   local drawpattern= pdfdraw.drawpattern
   drawloadpage(pagenum)
   local drawpage    = pdfdraw.drawpage
   local drawcache   = pdfdraw.drawcache
   local bbox,w,h, bh
   local pix
   local fd,name
   name        = pdfdraw.outname
   local  ctm = mupdf.fz_identity()
   ctm = mupdf.fz_concat(ctm, mupdf.fz_translate(0, - drawpage.mediabox.y1))
   ctm = mupdf.fz_concat(ctm, mupdf.fz_scale(drawzoom, - drawzoom))
   ctm = mupdf.fz_concat(ctm, mupdf.fz_rotate(drawrotate + drawpage.rotate))
   bbox = mupdf.fz_roundrect(mupdf.fz_transformrect(ctm, drawpage.mediabox))
   w = bbox.x1 - bbox.x0;
   h = bbox.y1 - bbox.y0;
   bh = h / drawbands;
   if NotNil(drawpattern) then
      fd = io.open(name,'wb')
      if (fd == nil) then
        die(fz_throw("ioerror: could not create raster file '%s'", name));
      end
      fd:write(string.format("P4\n%d %d\n", w, h));
   end
   pix = mupdf.fz_newpixmap(mupdf.pdf_devicergb, bbox.x0, bbox.y0, w, bh)
   mupdf.fz_clearpixmap(pix, 0xFF);
   for b = 0,  drawbands-1 do
      local dev, error
      dev = mupdf.fz_newdrawdevice(drawcache, pix)
```

```
      error = mupdf.pdf_runcontentstream(dev, ctm, xref, drawpage.resources, drawpage.contents)
      if (error>0) then
        die(fz_rethrow(error, "cannot draw page %d in PDF file '%s'", pagenum, basename))
      end
      mupdf.fz_freedevice(dev)
      if NotNil(drawpattern) then
        for y = 0, pix.h -1 do
          local column = y * pix.w * 4
           local dst = {}
           local bit = 0
          local r = 0
          for x = 0, pix.w-1 do
             local v = (1+(mupdf.uti_samples_arr_getitem(pix.samples,(x * 4 + 1) +
column)))*77
             v = v + (1+(mupdf.uti_samples_arr_getitem(pix.samples,(x * 4 + 2) + column)))*150
             v = v + (1+(mupdf.uti_samples_arr_getitem(pix.samples,(x * 4 + 3) + column)))*28
              v = math.floor(v/256)
             local d = 1
             if v > 200 then d = 0 end
              r = r + (d*2^(7-bit))
             bit = bit +1
             if bit == 8 then
               bit = 0
              dst[#dst+1] = string.char(r)
              r = 0
             end
          end
           if bit > 0 then
            dst[#dst+1] = string.char(r)
          end
           fd:write(table.concat(dst))
        end
      end
      pix.y = pix.y + bh;
      if (pix.y + pix.h > bbox.y1) then
        pix.h = bbox.y1 - pix.y;
      end
  end
  mupdf.fz_droppixmap(pix)
  if NotNil(drawpattern) then
    fd:close()
  end
  drawfreepage()
  print()
end
```

The complete binding is truly more difficult to debug: even if SWIG does an excellent work, it's necessary to manage the details of implementation of the library.
In this case `pdftopbm` does already an excellent work, it's well tested, stable and ready to use; the call of an external program is not so expensive compared to a plug in.

4 Conclusion

Lua code is much nearer to plain standard Lua: ConTEXt offers some shortcuts that is better to learn. For example `math.floor(string.gsub("10pt","pt","")*2^16)` can be replaced by `string.todimen("10pt")` and possibly other things related to print.

The algorithm that finds a good breakpoint is rather simple: for example the are some unwanted good breakpoints between a $\sum$ and the its subscript. This leads to break an object that should not be broken even if it has some white rows inside. A practical solution is to consider a line with thickness grater than 1 pixel (but it's better to use metric dimensions).

These ideas are also valid for scanned text but then we must take care of noise (and Leptonica can help a lot here).

Finally, it's better to consider carefully the opportunity of a binding. As shown with MuPFD, sometimes the traditional way is still the best way.

About µTalk

µTalk is a short and technical paper that shows some unusual, hopefully useful, ideas following the schema "figure → code". The main topic is always typographic programming in ConTEXt & Lua.