recode

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Contents

1 COPYING

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```

2 README

ABOUT

```
  recode -- scramble videos in time and space
  Copyright (C) 2011 Claude Heiland-Allen
```

DEPENDENCIES

```
  These programs are needed at build time:

    gcc
    make

  These programs are needed at run time:

    bash
    convert
    ecasound
    ffmpeg
    flac
    mkvmerge
    pnmcat
    pnmsplit
    ppmtoy4m
    puredata
    xargs
```

BUILD

```
  $ make -C src
```

USAGE

```
    $ mkdir recodes && cd recodes
    $ .../path/to/recode/src/recode.sh .../path/to/video.mp4
    ... wait a long time...
    $ mplayer video.mp4-RECODED.mpeg
```

NOTES

```
  * input videos must be 640x360 25fps with stereo sound
  * needs around 1GB/minute temporary space
  * processing time is O(length^2), which gets slow quickly
  * concurrent runs started in the same working directory will break
  * large files (>2GB) probably broken on 32bit systems
```

LEGAL

```
    recode -- scramble videos in time and space
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```

3 src/.gitignore

```
recode-audio-pass-1
recode-audio-pass-2
recode-audio-pass-3
recode-video-pass-1
recode-video-pass-2
recode-video.o
```

4 src/Makefile

```
CC=gcc
CFLAGS=-std=c99 -Wall -pedantic -Wextra -O3 -march=native


all: recode-audio-pass-1 recode-audio-pass-2 recode-audio-pass-3 recode-video-↙
    ↳ pass-1 recode-video-pass-2

clean:
        -rm recode-audio-pass-1 recode-audio-pass-2 recode-audio-pass-3 recode-↙
            ↳ video-pass-1 recode-video-pass-2 recode-video.o


recode-audio-pass-1: recode-audio-pass-1.c
```

```
	$(CC) $(CFLAGS) -o recode-audio-pass-1 recode-audio-pass-1.c -lm

recode-audio-pass-2: recode-audio-pass-2.c
	$(CC) $(CFLAGS) -o recode-audio-pass-2 recode-audio-pass-2.c -lm

recode-audio-pass-3: recode-audio-pass-3.c
	$(CC) $(CFLAGS) -o recode-audio-pass-3 recode-audio-pass-3.c -lm

recode-video-pass-1: recode-video-pass-1.c recode-video.h recode-video.o
	$(CC) $(CFLAGS) -o recode-video-pass-1 recode-video-pass-1.c recode-video.o -lm

recode-video-pass-2: recode-video-pass-2.c recode-video.h recode-video.o
	$(CC) $(CFLAGS) -o recode-video-pass-2 recode-video-pass-2.c recode-video.o -lm -fopenmp

recode-video.o: recode-video.c recode-video.h
	$(CC) $(CFLAGS) -o recode-video.o -c recode-video.c
```

5 src/recode-audio-pass-1.c

```
/*
  recode -- scramble videos in time and space
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*/

#include <math.h>
#include <stdio.h>

int main(int argc, char **argv) {
  if (argc < 2) { return 1; }
  FILE *o = fopen(argv[1], "wb");
  float k = 0.0f;
  while (1 == scanf("%f ", &k)) {
    k = log10f(k + 1.0f);
    if (1 != fwrite(&k, sizeof(float), 1, o)) { return 1; };
  }
  fclose(o);
  return 0;
}
```

6 src/recode-audio-pass-2.c

```c
/*
  recode -- scramble videos in time and space
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*/

#include <stdio.h>
#include <stdlib.h>
#include <sys/stat.h>

#define BINS 10
typedef float histogram[BINS];

static const float infinity = 1.0f / 0.0f;

int main(int argc, char **argv) {
  if (argc < 2) { return 1; }

  struct stat st;
  stat(argv[1], &st);
  int frames = st.st_size / sizeof(histogram);
  histogram *hist = malloc(frames * sizeof(histogram));
  FILE *hf = fopen(argv[1], "rb");
  if (1 != fread(hist, frames * sizeof(histogram), 1, hf)) { return 1; }
  fclose(hf);

  for (int f0 = 0; f0 < frames; ++f0) {
    int mf = -1;
    float ms = infinity;
    for (int f = 0; f < frames; ++f) {
      if (f0 == f) { continue; }
      float s = 0;
      for (int b = 0; b < BINS; ++b) {
        float d = hist[f0][b] - hist[f][b];
        s += d * d;
      }
      float df = f0 - f;
      df *= df;
      df *= df;
      s *= 1 + frames / df;
      if (s < ms) {
        mf = f;
        ms = s;
      }
    }
```

```
    printf("%d\n", mf);
  }
  return 0;
}
```

7 src/recode-audio-pass-3.c

```
/*
  recode -- scramble videos in time and space
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  along with this program.  If not, see <http://www.gnu.org/licenses/>.
*/

#include <math.h>
#include <stdio.h>
#include <stdint.h>
#include <stdlib.h>
#include <string.h>
#include <sys/stat.h>

static float   window[2048];
static float   blocks[4][2048][2];
static int16_t buffer[2048][2];
static int     which;
static int16_t output[512][2];

static const double pi = 3.141592653589793;

int main(int argc, char **argv) {
  if (argc < 3) { return 1; }
  for (int k = 0; k < 2048; ++k) {
    window[k] = 0.25 * (1.0 - cos(k * 2 * pi / 2047.0));
  }
  memset(blocks, 0, 4 * 2048 * 2 * sizeof(float));
  memset(buffer, 0, 2048 * 2 * sizeof(int16_t));
  memset(output, 0, 512 * 2 * sizeof(int16_t));
  which = 0;
  struct stat st;
  stat(argv[1], &st);
  int infilesize = st.st_size;
  FILE *i = fopen(argv[1], "rb");
  FILE *o = fopen(argv[2], "wb");
  int l = 0;
  const unsigned char h[44] = {'R','I','F','F', 0,0,0,0, 'W','A','V','E','f','m
      ↳ ','t',' ', 0x10,0,0,0, 1,0,2,0, 0x80,0xbb,0,0, 0,0xee,2,0, 4,0,0x10,0, '
```

```
      ↪ d','a','t','a', 0,0,0,0 };
  if (1 != fwrite(h, 44, 1, o)) { return 1; }
  int f;
  while (1 == scanf("%d\n", &f)) {
    if (0 <= f && f * 512 * 2 * ((int) sizeof(int16_t)) + 44 + 2048 * 2 * ((int)↙
        ↪  sizeof(int16_t)) <= infilesize) {
      if (0 != fseek(i, f * 512 * 2 * sizeof(int16_t) + 44, SEEK_SET)) { fprintf↙
          ↪ (stderr, "seek\n"); return 1; }
      if (1 != fread(buffer, 2048 * 2 * sizeof(int16_t), 1, i)) { fprintf(stderr↙
          ↪ , "read\n"); return 1; }
      for (int k = 0; k < 2048; ++k) {
        for (int c = 0; c < 2; ++c) {
          blocks[which][k][c] = window[k] * buffer[k][c];
        }
      }
    } else {
      memset(blocks[which], 0, 2048 * 2 * sizeof(float));
    }
    for (int k = 0; k < 512; ++k) {
      for (int c = 0; c < 2; ++c) {
        float o = 0;
        for (int b = which; b < which + 4; ++b) {
          int d = b - which;
          o += blocks[b % 4][512 * d + k][c];
        }
        output[k][c] = fminf(fmaxf(o, -32767), 32767);
      }
    }
    if (1 != fwrite(output, 512 * 2 * sizeof(int16_t), 1, o)) { fprintf(stderr, ↙
        ↪ "write\n"); return 1; }
    l += 512 * 2 * sizeof(int16_t);
    which = (which - 1 + 4) % 4;
  }
  fclose(i);
  if (0 != fseek(o, 4, SEEK_SET)) { fprintf(stderr, "seek'\n"); return 1; }
  unsigned char w[4];
  int m = l + 36;
  w[3] = (m >> 24) & 0xFF;
  w[2] = (m >> 16) & 0xFF;
  w[1] = (m >>  8) & 0xFF;
  w[0] = (m      ) & 0xFF;
  if (1 != fwrite(w, 4, 1, o)) { fprintf(stderr, "write'\n"); return 1; }
  if (0 != fseek(o, 40, SEEK_SET)) { fprintf(stderr, "seek''\n"); return 1; }
  w[3] = (l >> 24) & 0xFF;
  w[2] = (l >> 16) & 0xFF;
  w[1] = (l >>  8) & 0xFF;
  w[0] = (l      ) & 0xFF;
  if (1 != fwrite(w, 4, 1, o)) { fprintf(stderr, "write''\n"); return 1; }
  fclose(o);
  return 0;
}
```

8 src/recode-audio.pd

```
#N canvas 0 0 326 691 10;
#X obj 25 0 readsf~ 2;
#N canvas 394 0 949 474 \$0-overlap 0;
```

```
#X obj 33 37 inlet~;
#X obj 94 37 inlet~;
#X obj 94 80 *~;
#X obj 33 80 *~;
#X obj 33 102 rfft~;
#X obj 192 33 block~ 2048 4 1;
#X obj 192 55 table \$0-window 2048;
#X obj 171 84 tabreceive~ \$0-window;
#X obj 33 122 *~;
#X obj 60 123 *~;
#X obj 93 102 rfft~;
#X obj 93 122 *~;
#X obj 120 123 *~;
#X obj 170 147 table \$0-spectrum 2048;
#X obj 75 184 tabsend~ \$0-spectrum;
#X obj 383 55 loadbang;
#X msg 383 76 2048;
#X obj 383 97 until;
#X obj 383 118 f;
#X obj 437 119 + 1;
#X obj 437 140 mod 2048;
#X obj 383 171 expr 0.5 * ( 1 - cos ( 0.00306796 * $f1 ) );
#X obj 383 192 tabwrite \$0-window;
#X obj 383 145 t f f;
#X obj 75 211 bang~;
#X obj 75 232 outlet;
#X connect 0 0 3 0;
#X connect 1 0 2 0;
#X connect 2 0 10 0;
#X connect 3 0 4 0;
#X connect 4 0 8 0;
#X connect 4 0 8 1;
#X connect 4 1 9 0;
#X connect 4 1 9 1;
#X connect 7 0 2 1;
#X connect 7 0 3 1;
#X connect 8 0 14 0;
#X connect 9 0 14 0;
#X connect 10 0 11 0;
#X connect 10 0 11 1;
#X connect 10 1 12 0;
#X connect 10 1 12 1;
#X connect 11 0 14 0;
#X connect 12 0 14 0;
#X connect 15 0 16 0;
#X connect 16 0 17 0;
#X connect 17 0 18 0;
#X connect 18 0 19 0;
#X connect 18 0 23 0;
#X connect 19 0 20 0;
#X connect 20 0 18 1;
#X connect 21 0 22 0;
#X connect 23 0 21 0;
#X connect 23 1 22 1;
#X connect 24 0 25 0;
#X restore 13 43 pd \$0-overlap;
#X obj 31 23 dac~;
```

```
#X obj 67 185 t b b;
#X msg 67 205 10;
#X obj 67 226 until;
#X obj 101 248 * 2;
#X msg 117 206 1;
#X obj 67 165 t b b;
#X obj 86 311 until;
#X obj 130 331 + 1;
#X obj 86 332 f;
#X obj 67 247 f;
#X msg 158 207 0;
#X obj 86 353 tabread \$0-spectrum;
#X obj 86 374 +;
#X obj 126 375 f;
#X msg 129 301 0;
#X obj 67 268 t b f f b;
#X obj 68 414 f;
#X obj 78 442 /;
#X obj 78 463 list prepend;
#X obj 78 489 t a a;
#X obj 15 511 list append;
#X obj 167 -82 delay 1000;
#X msg 167 -61 \; pd quit 1;
#X obj 25 -88 loadbang;
#X obj 25 -67 t b b;
#X obj 25 -46 delay 1000;
#X msg 101 -61 \; pd dsp 1;
#X obj 69 112 t b b;
#X obj 14 113 t b b;
#X msg 58 68 0;
#X obj 15 532 print RECODE;
#X msg 25 -21 open temp/in.wav \, 1;
#X obj 13 91 spigot;
#X msg 28 66 1;
#X text 15 559 recode -- scramble videos in time and space \; Copyright
(C) 2011 Claude Heiland-Allen;
#X connect 0 0 1 0;
#X connect 0 0 2 0;
#X connect 0 1 1 1;
#X connect 0 1 2 1;
#X connect 0 2 24 0;
#X connect 0 2 32 0;
#X connect 1 0 35 0;
#X connect 3 0 4 0;
#X connect 3 1 7 0;
#X connect 4 0 5 0;
#X connect 5 0 12 0;
#X connect 6 0 12 1;
#X connect 7 0 12 1;
#X connect 8 0 3 0;
#X connect 8 1 13 0;
#X connect 9 0 11 0;
#X connect 10 0 11 1;
#X connect 11 0 10 0;
#X connect 11 0 14 0;
#X connect 12 0 6 0;
#X connect 12 0 18 0;
```

```
#X connect 13 0 11 1;
#X connect 14 0 15 0;
#X connect 15 0 16 0;
#X connect 15 0 19 1;
#X connect 16 0 15 1;
#X connect 17 0 15 1;
#X connect 18 0 19 0;
#X connect 18 1 9 0;
#X connect 18 2 20 1;
#X connect 18 3 17 0;
#X connect 19 0 20 0;
#X connect 20 0 21 0;
#X connect 21 0 22 0;
#X connect 22 0 23 1;
#X connect 22 1 21 1;
#X connect 23 0 33 0;
#X connect 24 0 25 0;
#X connect 26 0 27 0;
#X connect 27 0 28 0;
#X connect 27 1 29 0;
#X connect 28 0 34 0;
#X connect 28 0 36 0;
#X connect 30 0 8 0;
#X connect 30 1 21 1;
#X connect 31 0 23 0;
#X connect 31 1 30 0;
#X connect 32 0 35 1;
#X connect 34 0 0 0;
#X connect 35 0 31 0;
#X connect 36 0 35 1;
```

9 src/recode.sh

```
#!/bin/bash
# recode -- scramble videos in time and space
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#
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# GNU General Public License for more details.
#
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# along with this program.  If not, see <http://www.gnu.org/licenses/>.
T0="$(date --iso=s)"
R="$(dirname "$(readlink -f "${0}")")"
w=640
h=360
mkdir thumbs slices temp
"${R}/recode-video-pass-1" "${1}" "${w}" "${h}" "temp/frames.hist" &&
"${R}/recode-video-pass-2" "${1}" "${w}" "${h}" "temp/frames.hist" |
xargs -n 577 |
```

```
while read f ts
do
  echo $ts | xargs -n 32 pnmcat -lr | pnmsplit - slices/%d 2>/dev/null
  cd slices
  ls -1 | sort -n | xargs -n 18 pnmcat -tb
  cd ..
done |
ppmtoy4m -S444 -F25:1 |
ffmpeg -f yuv4mpegpipe -i - -vcodec libx264 -vpre lossless_medium temp/video.mkv &&
ffmpeg -i "${1}" -vn temp/audio.wav &&
ecasound -f:s16_le,2,48000 -i:resample-hq,auto,temp/audio.wav -o:temp/in.wav &&
pd -path . -stderr -r 48000 -batch -open "${R}/recode-audio.pd" 2>&1 |
grep "^RECODE:" | sed "s|^RECODE:||g" | tr " " "\n" |
"${R}/recode-audio-pass-1" temp/audio.hist &&
"${R}/recode-audio-pass-2" temp/audio.hist |
"${R}/recode-audio-pass-3" temp/in.wav temp/out.wav &&
ecasound -i:temp/out.wav -o:temp/out2.wav &&
flac --best --verify temp/out2.wav -o temp/audio.flac &&
mkvmerge -o "$(basename "${1}")-RECODED.mkv" temp/video.mkv temp/audio.flac &&
ffmpeg -i "$(basename "${1}")-RECODED.mkv" -target pal-dvd "$(basename "${1}")-RECODED.mpeg"
T1="$(date --iso=s)"
echo -e "\n\n\n${T0} START\n${T1} END"
```

10 src/recode-video.c

```
/*
  recode -- scramble videos in time and space
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*/

#define _POSIX_C_SOURCE 2

#include <math.h>
#include <stdlib.h>
#include <string.h>

#include "recode-video.h"

static int bpopcmp(const void *x, const void *y) {
  const struct bucket *a = x;
  const struct bucket *b = y;
  if (a->pop >  b->pop) { return -1; }
```

```
  if (a->pop <  b->pop) { return  1; }
  return 0;
}

static int bbidcmp(const void *x, const void *y) {
  const struct bucket *a = x;
  const struct bucket *b = y;
  if (a->bid <  b->bid) { return -1; }
  if (a->bid >  b->bid) { return  1; }
  return 0;
}

static int min(int a, int b) { return a < b ? a : b; }
static int max(int a, int b) { return a > b ? a : b; }

void calculate_shist(struct shist *sh, struct histogram *hh, unsigned char *rgb,↙
   ↪  int rgb_w, int rgb_h, int sh_x, int sh_y, int sh_w, int sh_h) {
  int bid = 0;
  for (int i = 0; i < 12; ++i) {
    for (int j = 0; j < 6; ++j) {
      for (int k = 0; k < 8; ++k) {
        hh->b[i][j][k].pop = 0.0f;
        hh->b[i][j][k].bid = bid++;
      }
    }
  }
  for (int y = sh_y; y < sh_y + sh_h; ++y) {
    for (int x = sh_x; x < sh_x + sh_w; ++x) {
      unsigned char *p = rgb + 3 * rgb_w * y + 3 * x;
      float r = *p++ / 255.0f;
      float g = *p++ / 255.0f;
      float b = *p   / 255.0f;
      // rgb to hsv
      float mi = fminf(fminf(r, g), b);
      float ma = fmaxf(fmaxf(r, g), b);
      float h = 0; float s = 0; float v = ma;
      if (v > 0) {
        r /= v; g /= v; b /= v; mi /= v; ma /= v; s = ma - mi;
        if (s > 0) {
          r = (r - mi) / s; g = (g - mi) / s; b = (b - mi) / s;
          mi = fminf(fminf(r, g), b); ma = fmaxf(fmaxf(r, g), b);
          if (ma == r) { h = 2 * (g - b); if (h < 0) { h += 12; }
          } else if (ma == g) { h = 4 + 2 * (b - r);
          } else /* ma == b) */ { h = 8 + 2 * (r - g); }
        }
      }
      int bh = floor(h);            bh = min(max(0, bh), 11);
      int bs = floor(5 * s + 0.5);  bs = min(max(0, bs),  5);
      int bv = floor(7 * v + 0.5);  bv = min(max(0, bv),  7);
      hh->b[bh][bs][bv].pop += 1.0f;
    }
  }
  qsort(hh, 12 * 6 * 8, sizeof(struct bucket), bpopcmp);
  memcpy(sh, hh, sizeof(struct shist));
  qsort(sh, BUCKETS, sizeof(struct bucket), bbidcmp);
  for (int i = 0; i < BUCKETS; ++i) {
    sh->b[i].pop /= (sh_w * sh_h);
```

```
  }
}

FILE *open_video(const char *vfile) {
  const char *fmt = "ffmpeg -i '%s' -f image2pipe pipe:-.ppm";
  int len = strlen(fmt) + strlen(vfile);
  char *cmd = malloc(len);
  snprintf(cmd, len, fmt, vfile);
  return popen(cmd, "r");
}

int read_video(FILE *video, unsigned char *rgb, int width, int height) {
  char hdr[64];
  char hdr2[64];
  snprintf(hdr, 60, "P6\n%d %d\n255\n", width, height);
  if (1 == fread(hdr2, strlen(hdr), 1, video)) {
    hdr2[strlen(hdr)] = 0;
    if (strcmp(hdr, hdr2)) { return 0; }
    if (1 != fread(rgb, width * height * 3, 1, video)) { return 0; }
    return 1;
  } else {
    return 0;
  }
}

void close_video(FILE *video) {
  pclose(video);
}
```

11 src/recode-video.h

```
/*
  recode -- scramble videos in time and space
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*/

#ifndef RECODE_VIDEO_H
#define RECODE_VIDEO_H 1

#include <stdint.h>
#include <stdio.h>

#define BUCKETS 16
```

```
struct bucket {
  float pop;
  uint32_t bid;
};

struct shist {
  struct bucket b[BUCKETS];
};

struct histogram {
  struct bucket b[12][6][8];
};

void calculate_shist(struct shist *sh, struct histogram *hh, unsigned char *rgb, int rgb_w, int rgb_h, int sh_x, int sh_y, int sh_w, int sh_h);

FILE *open_video(const char *vfile);
int read_video(FILE *video, unsigned char *rgb, int width, int height);
void close_video(FILE *video);

#endif
```

12 src/recode-video-pass-1.c

```
/*
  recode -- scramble videos in time and space
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  along with this program.  If not, see <http://www.gnu.org/licenses/>.
*/

#define _POSIX_C_SOURCE 2

#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#include "recode-video.h"

int main(int argc, char **argv) {
  if (argc < 5) { return 1; }

  const char *thfmt = "convert ppm:- -geometry 60x60 'thumbs/%08d.ppm'";
  int thlen = strlen(thfmt) + 8;
  char *thcmd = malloc(thlen);
```

```
  int width = atoi(argv[2]);
  int height = atoi(argv[3]);
  int crop = (width - height) >> 1;

  unsigned char *rgb = malloc(width * height * 3);
  struct histogram *hh = malloc(sizeof(struct histogram));
  struct shist *sh = malloc(sizeof(struct shist));
  FILE *slog = fopen(argv[4], "wb");

  FILE *ppm = open_video(argv[1]);
  int f = 0;
  while (read_video(ppm, rgb, width, height)) {
    // whole center histogram
    calculate_shist(sh, hh, rgb, width, height, crop, 0, height, height);
    if (1 != fwrite(sh, sizeof(struct shist), 1, slog)) { return 1; }
    // output thumbnail
    snprintf(thcmd, thlen, thfmt, f++);
    FILE *thumb = popen(thcmd, "w");
    fprintf(thumb, "P6\n%d %d 255\n", height, height);
    fflush(thumb);
    for (int j = 0; j < height; ++j) {
      if (1 != fwrite(rgb + crop * 3 + j * width * 3, height * 3, 1, thumb)) { ↙
          ↳ return 1; };
    }
    pclose(thumb);
  }
  close_video(ppm);

  fclose(slog);
  free(rgb);
  free(hh);
  free(sh);
  free(thcmd);
  return 0;
}
```

13 src/recode-video-pass-2.c

```
/*
  recode -- scramble videos in time and space
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  along with this program.  If not, see <http://www.gnu.org/licenses/>.
*/

#include <math.h>
```

```
20  #include <stdio.h>
    #include <stdlib.h>
    #include <string.h>
    #include <sys/stat.h>

25  #include "recode-video.h"

    static int match_shist(struct shist *shs, int count, struct shist *sh) {
      int mi_i = -1;
      float mi_d = 1.0f / 0.0f;
30    for (int i = 0; i < count; ++i) {
        float d = 0;
        int b = 0;
        int bi = 0;
        while (b < BUCKETS || bi < BUCKETS) {
35        if (b < BUCKETS && bi < BUCKETS) {
            if (shs[i].b[bi].bid == sh->b[b].bid) {
              d += powf(shs[i].b[bi++].pop - sh->b[b++].pop, 2);
            } else if (shs[i].b[bi].bid < sh->b[b].bid) {
              d += powf(shs[i].b[bi++].pop, 2);
40          } else /* (shs[i].b[bi].bid > sh->b[b].bid) */ {
              d += powf(sh->b[b++].pop, 2);
            }
          } else {
            while (bi < BUCKETS) {
45            d += powf(shs[i].b[bi++].pop, 2);
            }
            while (b < BUCKETS) {
              d += powf(sh->b[b++].pop, 2);
            }
50        }
        }
        if (d < mi_d) {
          mi_i = i;
          mi_d = d;
55      }
      }
      return mi_i;
    }

60  int main(int argc, char **argv) {

      if (argc < 5) { return 1; }

      int width = atoi(argv[2]);
65    int height = atoi(argv[3]);

      int cell = 20;
      int cols = width  / cell;
      int rows = height / cell;
70    int *grid = malloc(cols * rows * sizeof(int));

      unsigned char *rgb = malloc(width * height * 3);
      struct histogram *hh = malloc(rows * sizeof(struct histogram));
      struct shist *sh = malloc(rows * sizeof(struct shist));
75
      struct stat st;
```

```
  stat(argv[4], &st);
  int count = st.st_size / sizeof(struct shist);
  struct shist *shs = malloc(count * sizeof(struct shist));
  FILE *slog = fopen(argv[4], "rb");
  if (1 != fread(shs, count * sizeof(struct shist), 1, slog)) { return 1; }
  fclose(slog);

  FILE *ppm = open_video(argv[1]);
  int f = 0;
  while (read_video(ppm, rgb, width, height)) {
    printf("%08d\n", f);
    // tile histograms
    {
      int i;
      #pragma omp parallel for private(i) schedule(static, 1)
      for (int j = 0; j < rows; ++j) {
        for (i = 0; i < cols; ++i) {
          calculate_shist(&sh[j], &hh[j], rgb, width, height, i * cell, j * cell
              , cell, cell);
          grid[j * cols + i] = match_shist(shs, count, &sh[j]);
        }
      }
    }
    for (int j = 0; j < rows; ++j) {
      for (int i = 0; i < cols; ++i) {
        printf("thumbs/%08d.ppm\n", grid[j * cols + i]);
      }
    }
  }
  close_video(ppm);

  free(rgb);
  free(shs);
  free(sh);
  free(hh);
  return 0;
}
```

14 v2/Makefile

```
recoda-live: recoda-live.c
	gcc -std=c99 -Wall -Wextra -pedantic -O3 -march=native -o recoda-live
	    recoda-live.c -lfftw3f -ljack -lm -g

recoda: recoda.c
	gcc -std=c99 -Wall -Wextra -pedantic -O3 -march=native -o recoda recoda.
	    c -lfftw3f -lsndfile -lm -g
```

15 v2/recoda.c

```
#include <complex.h>
#include <math.h>
#include <string.h>
#include <fftw3.h>
#include <sndfile.h>
```

```
#define twopi 6.283185307179586

#define CHANNELS 2
#define OCTAVES 11
#define FFTSIZE (1 << OCTAVES)
#define OVERLAP 4

inline float cnormf(float _Complex f) {
  return crealf(f) * crealf(f) + cimagf(f) * cimagf(f);
}

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

  if (argc != 4) {
    fprintf(stderr, "usage: %s source.wav control.wav out.wav\n", argv[0]);
    return 1;
  }

  float *window = fftwf_malloc(sizeof(*window) * FFTSIZE);
  for (int i = 0; i < FFTSIZE; ++i) {
    window[i] = 0.5 * (1 - cos(i * twopi / FFTSIZE));
  }
  float *fft_in = fftwf_malloc(sizeof(*fft_in) * FFTSIZE);
  float _Complex *fft_out = fftwf_malloc(sizeof(*fft_out) * FFTSIZE * 2);
  fftwf_plan plan = fftwf_plan_dft_r2c_1d(FFTSIZE, fft_in, fft_out, FFTW_PATIENT↙
      ↳ );

  SF_INFO src_info = { 0, 0, 0, 0, 0, 0 };
  SNDFILE *src = sf_open(argv[1], SFM_READ, &src_info);
  float *src_audio = fftwf_malloc(sizeof(*src_audio) * CHANNELS * src_info.↙
      ↳ frames);
  sf_readf_float(src, src_audio, src_info.frames);
  sf_close(src);

  SF_INFO in_info = { 0, 0, 0, 0, 0, 0 };
  SNDFILE *in = sf_open(argv[2], SFM_READ, &in_info);
  float *in_audio = fftwf_malloc(sizeof(*in_audio) * CHANNELS * in_info.frames);
  sf_readf_float(in, in_audio, in_info.frames);
  sf_close(in);

  int max_count = src_info.frames / (FFTSIZE / OVERLAP);
  float *metrics = fftwf_malloc(sizeof(*metrics) * OCTAVES * max_count);
  float *p = metrics;
  int count = 0;
  for (int t = 0; t + FFTSIZE <= src_info.frames; t += FFTSIZE / OVERLAP) {
    // window to mono
    for (int i = t; i < t + FFTSIZE; ++i) {
      fft_in[i - t] = window[i - t] * (src_audio[CHANNELS * i + 0] + src_audio[↙
          ↳ CHANNELS * i + 1]);
    }
    fftwf_execute(plan);
    // compute metric
    for (int i = 1; i < FFTSIZE; i <<= 1) {
      float sum = 0;
      for (int k = i; k < (i << 1); ++k) {
        sum += cnormf(fft_out[k]);
      }
```

```
      *p++ = sum;
    }
    count++;
  }

  float *out_audio = fftwf_malloc(sizeof(*out_audio) * CHANNELS * in_info.frames);
  memset(out_audio, 0, sizeof(*out_audio) * CHANNELS * in_info.frames);
  for (int t = 0; t + FFTSIZE <= in_info.frames; t += FFTSIZE / OVERLAP) {
    // window to mono
    for (int i = t; i < t + FFTSIZE; ++i) {
      fft_in[i - t] = window[i - t] * (in_audio[CHANNELS * i + 0] + in_audio[CHANNELS * i + 1]);
    }
    fftwf_execute(plan);
    // compute metric
    float current[OCTAVES];
    p = current;
    int count2 = 0;
    for (int i = 1; i < FFTSIZE; i <<= 1) {
      float sum = 0;
      for (int k = i; k < (i << 1); ++k) {
        sum += cnormf(fft_out[k]);
      }
      *p++ = sum;
      count2++;
    }
    // find best match
    float minsum = 1.0f / 0.0f;
    int mini = 0;
    p = metrics;
    for (int i = 0; i < count; ++i) {
      float sum = 0;
      for (int j = 0; j < count2; ++j) {
        float d = current[j] - *p++;
        sum += d * d;
      }
      if (sum < minsum) {
        minsum = sum;
        mini = i;
      }
    }
    // regurgitate with windowing
    for (int i = 0; i < FFTSIZE; ++i) {
      for (int c = 0; c < CHANNELS; ++c) {
        out_audio[CHANNELS * (t + i) + c] +=
          window[i] * src_audio[CHANNELS * (mini * FFTSIZE / OVERLAP + i) + c];
      }
    }
  }

  // write output
  SF_INFO out_info = { 0, src_info.samplerate, CHANNELS, SF_FORMAT_WAV | SF_FORMAT_FLOAT, 0 ,0 };
  SNDFILE *out = sf_open(argv[3], SFM_WRITE, &out_info);
  sf_writef_float(out, out_audio, in_info.frames);
  sf_close(out);
```

```
115
  return 0;
}
```

16 v2/recoda-live.c

```
#include <complex.h>
#include <math.h>
#include <stdlib.h>
#include <string.h>
#include <fftw3.h>
#include <jack/jack.h>

#define twopi 6.283185307179586

#define SR 48000
#define CHANNELS 2
#define CHUNKSIZE 2048
#define OVERLAP 8
#define HOPSIZE 256
#define DURATION (SR * 60 * 5)


inline float cnormf(float _Complex f) {
  return crealf(f) * crealf(f) + cimagf(f) * cimagf(f);
}

struct {
  float *fft_in;
  float _Complex *fft_out;
  fftwf_plan plan;
  float *window;
  int alength;
  float *audio[CHANNELS];
  int acount;
  int mcount;
  int bcount;
  float *metric[CHANNELS];
  int bindex;
  int wcount;
  struct { int j; float a; } rblock[CHANNELS][OVERLAP];
  int hcount;
  jack_client_t *client;
  jack_port_t *iport[CHANNELS];
  jack_port_t *oport[CHANNELS];
} S;

int process_callback(jack_nframes_t jnframes, void *arg) {
  (void) arg;
  int nframes = jnframes;

  float *in[CHANNELS];
  float *out[CHANNELS];
  for (int c = 0; c < CHANNELS; ++c) {
    in[c] = (jack_default_audio_sample_t *) jack_port_get_buffer(S.iport[c], ↙
        ↪ nframes);
    out[c] = (jack_default_audio_sample_t *) jack_port_get_buffer(S.oport[c], ↙
```

```
      ↳ nframes);
  }

  for (int i = 0; i < nframes; ++i) {

    // clear output
    for (int c = 0; c < CHANNELS; ++c) {
      out[c][i] = 0;
    }

    // record audio
    for (int c = 0; c < CHANNELS; ++c) {
      S.audio[c][S.acount] = in[c][i];
      if (S.acount >= S.alength - CHUNKSIZE) {
        S.audio[c][S.acount + CHUNKSIZE - S.alength] = in[c][i];
      }
    }
    S.acount++;
    if (S.acount == S.alength) {
      S.acount = CHUNKSIZE;
      S.bindex = 0;
    }

    // process every hop
    S.hcount++;
    if (S.hcount == HOPSIZE) {
      for (int c = 0; c < CHANNELS; ++c) {
        // analyse block
        for (int j = 0; j < CHUNKSIZE; ++j) {
          int k = S.acount - CHUNKSIZE + j;
          S.fft_in[j] = S.window[j] * S.audio[c][k];
        }
        fftwf_execute(S.plan);
        float *p = S.metric[c] + S.bindex * S.mcount;
        for (int j = 1; j < CHUNKSIZE >> 1; j <<= 1) {
          float sum = 0;
          for (int k = j; k < (j << 1); ++k) {
            sum += cnormf(S.fft_out[k]);
          }
          *p++ = sum;
        }
        // shuffle down read pointers
        for (int j = 1; j < OVERLAP; ++j) {
          S.rblock[c][j-1] = S.rblock[c][j];
        }
        // find best matching block
        int c2 = (c + 1) % CHANNELS;
        p = S.metric[c2];
        float minsum = 1.0f / 0.0f;
        float mingain = 0.0f;
        int minj = 0;
        for (int j = 0; j < S.bcount; ++j) {
          float *q = S.metric[c] + S.bindex * S.mcount;
          float sum = 0;
          float sump = 0;
          float sumq = 0;
          for (int k = 0; k < S.mcount; ++k) {
```

```
            sump += *p * *p;
            sumq += *q * *q;
            float d = *p++ - *q++;
            sum += d * d;
          }
          float csum = (sum * sum) / (sump * sumq);
          if (csum < minsum) {
            minsum = csum;
            mingain = (1e-20 + sumq) / (1e-20 + sump);
            minj = j;
          }
        }
        S.rblock[c][OVERLAP-1].j = minj;
        S.rblock[c][OVERLAP-1].a = sqrtf(sqrtf(mingain));
      }
      S.bindex++;
      S.wcount = 0;
      S.hcount = 0;
    }

    // resynthesize output
    for (int c = 0; c < CHANNELS; ++c) {
      int c2 = (c + 1) % CHANNELS;
      for (int j = 0; j < OVERLAP; ++j) {
        out[c][i] += S.rblock[c][j].a * S.window[(OVERLAP - j - 1) * HOPSIZE + S.wcount] * S.audio[c2][S.rblock[c][j].j * HOPSIZE + (OVERLAP - j - 1) * HOPSIZE + S.wcount];
      }
    }
    S.wcount++;

  } // for i
  return 0;
}

/* JACK error callback */
void error_callback(const char *desc) {
  fprintf(stderr, "JACK error: %s\n", desc);
}

/* JACK shutdown callback */
void shutdown_callback(void *arg) {
  (void) arg;
  exit(1);
}

/* exit callback */
void atexit_callback(void) {
  jack_client_close(S.client);
}

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

  memset(&S, 0, sizeof(S));

  S.fft_in = fftwf_malloc(sizeof(*S.fft_in) * CHUNKSIZE);
  S.fft_out = fftwf_malloc(sizeof(*S.fft_out) * CHUNKSIZE * 2);
```

```
  S.plan = fftwf_plan_dft_r2c_1d(CHUNKSIZE, S.fft_in , S.fft_out , FFTW_PATIENT);

  S.window = fftwf_malloc(sizeof(*S.window) * CHUNKSIZE);
  for (int i = 0; i < CHUNKSIZE; ++i) {
    S.window[i] = 0.5 * (1 - cos(i * twopi / CHUNKSIZE));
  }
  float gain = 0;
  for (int i = 0; i < OVERLAP; ++i)
  {
    gain += S.window[i * HOPSIZE];
  }
  for (int i = 0; i < CHUNKSIZE; ++i) {
    S.window[i] /= gain;
  }

  S.alength = (DURATION / HOPSIZE) * HOPSIZE;
  for (int c = 0; c < CHANNELS; ++c) {
    S.audio[c] = fftwf_malloc(sizeof(*S.audio) * S.alength);
  }
  S.acount = 0;

  S.mcount = 0;
  for (int j = 1; j < CHUNKSIZE >> 1; j <<= 1) {
    S.mcount++;
  }
  S.bcount = (S.alength - CHUNKSIZE) / HOPSIZE;
  for (int c = 0; c < CHANNELS; ++c) {
    S.metric[c] = fftwf_malloc(sizeof(*S.metric) * S.bcount * S.mcount);
    memset(S.metric[c], 0, sizeof(*S.metric) * S.bcount * S.mcount);
  }
  S.bindex = 0;

  S.wcount = 0;
  for (int c = 0; c < CHANNELS; ++c) {
    for (int j = 0; j < OVERLAP; ++j) {
      S.rblock[c][j].j = 0;
      S.rblock[c][j].a = 0.0f;
    }
  }
  S.hcount = HOPSIZE - CHUNKSIZE;

  if (!(S.client = jack_client_new("recoda"))) {
    fprintf (stderr, "jack server not running?\n");
    return 1;
  }
  atexit(atexit_callback);
  jack_set_process_callback(S.client , process_callback , 0);
  jack_on_shutdown(S.client , shutdown_callback , 0);

  for (int c = 0; c < CHANNELS; ++c) {
    char name[90];
    snprintf(name, 100, "input_%d", c + 1);
    S.iport[c] = jack_port_register(S.client , name, JACK_DEFAULT_AUDIO_TYPE, ↙
        ↳ JackPortIsInput , 0);
    snprintf(name, 100, "output_%d", c + 1);
    S.oport[c] = jack_port_register(S.client , name, JACK_DEFAULT_AUDIO_TYPE, ↙
        ↳ JackPortIsOutput , 0);
```

```
  }
  if (jack_activate(S.client)) {
    fprintf(stderr, "cannot activate JACK client");
    return 1;
  }

  // must be activated before connecting JACK ports
  const char **ports;
  if ((ports = jack_get_ports(S.client, NULL, NULL, JackPortIsPhysical |
      ↪ JackPortIsInput))) {
    /* connect up to two physical playback ports */
    int i = 0;
    while (ports[i] && i < 2) {
      if (jack_connect(S.client, jack_port_name(S.oport[i]), ports[i])) {
        fprintf(stderr, "cannot connect playback port\n");
      }
      i++;
    }
    free(ports);
  }
  if ((ports = jack_get_ports(S.client, NULL, NULL, JackPortIsPhysical |
      ↪ JackPortIsOutput))) {
    /* connect up to two physical capture ports */
    int i = 0;
    while (ports[i] && i < 2) {
      if (jack_connect(S.client, ports[i], jack_port_name(S.iport[i]))) {
        fprintf(stderr, "cannot connect capture port\n");
      }
      i++;
    }
    free(ports);
  }

  while (1) {
    sleep(60);
  }

  return 0;
}
```