

# USING COMPILED CODE IN POMP

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### 1. A TWO-DIMENSIONAL ORNSTEIN-UHLENBECK PROCESS.

Let's look again at our example of the discrete-time 2-D Ornstein-Uhlenbeck process with normal measurement error. Recall that the unobserved Ornstein-Uhlenbeck (OU) process  $X_t \in \mathbb{R}^2$  satisfies

$$X_t = A X_{t-1} + \xi_t.$$

The observation process is

$$Y_t = B X_t + \varepsilon_t.$$

In these equations,  $A$  and  $B$  are  $2 \times 2$  constant matrices;  $\xi_t$  and  $\varepsilon_t$  are mutually-independent families of i.i.d. bivariate normal random variables. We let  $\sigma\sigma^T$  be the variance-covariance matrix of  $\xi_t$ , where  $\sigma$  is lower-triangular; likewise, we let  $\tau\tau^T$  be that of  $\varepsilon_t$ .

Since many of the methods we will use require us to simulate the process and/or measurement models many times, it is a good idea to use native (compiled) codes for the computational heavy lifting. The package includes some C codes that were written to implement the OU example. Read the source (file 'ou2.c') for details.

```
> ou2.rprocess <- function(xstart, times, params,
+   paramnames, ...) {
+   nvar <- nrow(xstart)
+   npar <- nrow(params)
+   nrep <- ncol(xstart)
+   ntimes <- length(times)
+   parindex <- match(paramnames, rownames(params)) -
+     1
+   array(.C("ou2_adv", X = double(nvar * nrep *
+     ntimes), xstart = as.double(xstart), par = as.double(params),
+     times = as.double(times), n = as.integer(c(nvar,
+     npar, nrep, ntimes)), parindex = as.integer(parindex),
+     DUP = FALSE, NAOK = TRUE, PACKAGE = "pomp")$X,
+     dim = c(nvar, nrep, ntimes), dimnames = list(rownames(xstart),
+     NULL, NULL))
+ }
```

```
> ou2.dprocess <- function(x, times, params, log,
+   ...) {
+   nvar <- nrow(x)
+   npar <- nrow(params)
```

```

+   nrep <- ncol(x)
+   ntimes <- length(times)
+   parindex <- match(paramnames, rownames(params)) -
+     1
+   array(.C("ou2_pdf", d = double(nrep * (ntimes -
+     1)), X = as.double(x), par = as.double(params),
+     times = as.double(times), n = as.integer(c(nvar,
+     npar, nrep, ntimes)), parindex = as.integer(parindex),
+     give_log = as.integer(log), DUP = FALSE,
+     NAOK = TRUE, PACKAGE = "pomp")$d, dim = c(nrep,
+     ntimes - 1))
+ }
> ou2 <- pomp(times = seq(1, 100), data = rbind(y1 = rep(0,
+   100), y2 = rep(0, 100)), t0 = 0, rprocess = ou2.rprocess,
+   dprocess = ou2.dprocess, dmeasure = "normal_dmeasure",
+   rmeasure = "normal_rmeasure", obsnames = c("y1",
+     "y2"), paramnames = c("alpha.1", "alpha.2",
+     "alpha.3", "alpha.4", "sigma.1", "sigma.2",
+     "sigma.3", "tau"), statenames = c("x1",
+     "x2"))

```

We'll specify some parameters:

```

> p <- c(alpha.1 = 0.9, alpha.2 = 0, alpha.3 = 0,
+   alpha.4 = 0.99, sigma.1 = 1, sigma.2 = 0,
+   sigma.3 = 2, tau = 1, x1.0 = 50, x2.0 = -50)

> tic <- Sys.time()
> ou2 <- simulate(ou2, params = p, nsim = 1000,
+   seed = 800733088)[[1]]
> toc <- Sys.time()
> print(toc - tic)

```

Time difference of 4.252287 secs

Fig. 1 plots the data.

The `pomp` object we just created is included in the package: use `data(ou2)` to retrieve it.

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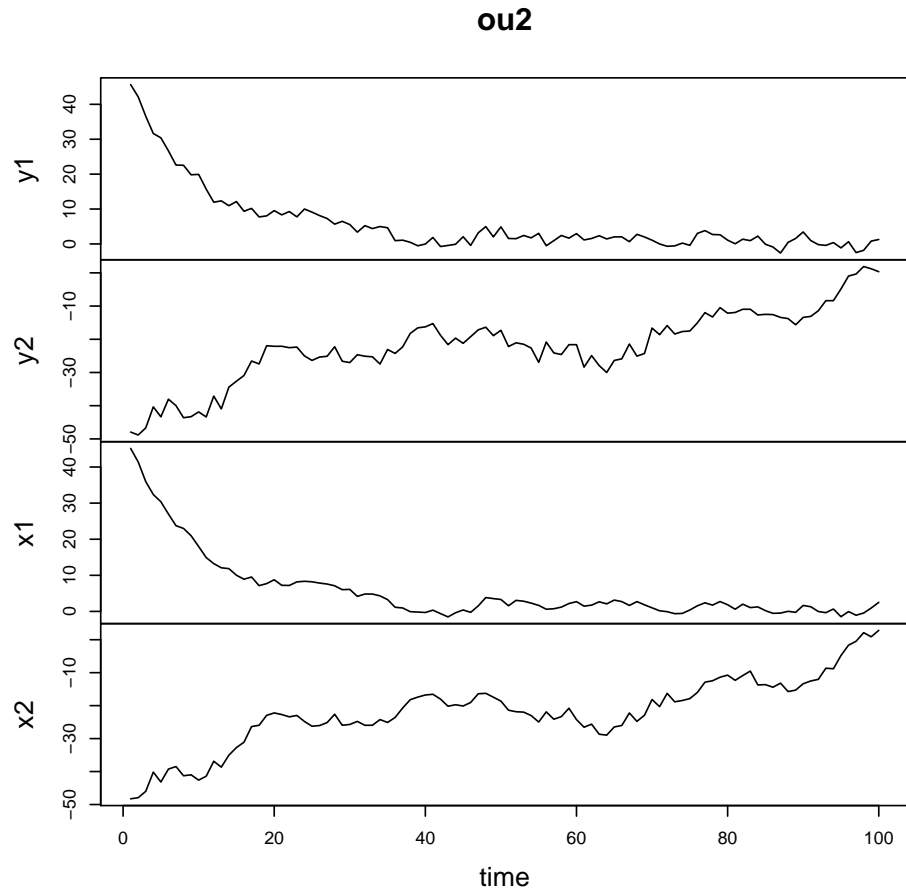


FIGURE 1. One realization of the two-dimensional OU process.