Algorithm 1: Latent Dirichlet Allocation using Variational Expectation-Maximization

input : A corpus collection of D documents
output: γ (DxK matrix), λ (KxV matrix), ϕ (DxNxK)

initialize parameters;
Expectation-step: Optimize the variational parameters (γ_d, $\phi_d \in D$), λ, and likelihood;
while *the ELBO has not not converged* **do**
    loglikelihood :=0;
    for d = *1 to* D **do**
        repeat
            for n = *1 to* N **do**
                for k = *1 to* K **do**
                    $\phi_{dnk}^{t+1} := \exp(\Psi(\gamma_{dk}) + \Psi(\lambda_{k,n^j})$ - $\Psi(\sum_i \lambda_{k,n^j})$) ;
                end
                normalize ϕ_{dnk}^{t+1} to sum 1;
            end
            $\gamma^{t+1} := \alpha + \sum_{n=1}^{N} \phi_{dn}$
        until *converge of* ϕ_d *and* γd;
    end
    for k = *1 to* K **do**
        for j = *1 to* V **do**
            $\lambda_{kj} := \eta + \sum_{d=1}^{D} \sum_{n=1}^{N} \phi_{dnk} w_{dn}^{j}$;
        end
        normalize λ_k to sum 1;
    end
    loglikelihood := loglikelihood + $L(\lambda, \phi, \gamma; \alpha, \eta)$;
end
Maximization Step for lower bound on the likelihood;
for d = *1 to* D **do**
    for k = *1 to* K **do**
        for j = *1 to* V **do**
            update η ;
        end
    end
    update α ;
end
if *Likelihood converged* **then**
    return γ, λ, ϕ;
else
    repeat E-M algorithm;
end