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8. Appendix

For $t_0 \leq t_1 \leq t_2$, we have:

$$
\begin{aligned}
d\left(x_n(t_1), x_{n-1}(t_1)\right) &- d\left(x_n(t_2), x_{n-1}(t_2)\right) \\
&\leq \left|d\left(x_n(t_1), x_{n-1}(t_1)\right) - d\left(x_n(t_2), x_{n-1}(t_2)\right)\right| \\
&\leq \frac{1}{\Gamma(q)}\left[\left|\int_{t_0}^{t_1}(t_1-s)^{q-1}D(s)ds - \int_{t_0}^{t_2}(t_2-s)^{q-1}D(s)ds\right|\right] \\
&= \frac{1}{\Gamma(q)}\left[\left|\int_{t_0}^{t_1}\left\{(t_1-s)^{q-1}-(t_2-s)^{q-1}\right\}D(s)ds - \int_{t_1}^{t_2}(t_2-s)^{q-1}D(s)ds\right|\right] \\
&\leq \frac{2M}{\Gamma(q)}\left[\left|\int_{t_0}^{t_1}\left\{(t_1-s)^{q-1}-(t_2-s)^{q-1}\right\}ds + \int_{t_1}^{t_2}(t_2-s)^{q-1}ds\right|\right] \\
&= \frac{2M}{q\Gamma(q)}\left[\left|(t_1-t_0)^q-(t_2-t_0)^q+2(t_2-t_1)^q\right|\right] \\
&\leq \frac{4M}{q\Gamma(q)}(t_2-t_1)^q = \frac{4M}{\Gamma(q+1)}(t_2-t_1)^q,
\end{aligned}
$$

where $D(s) = d(f(s, x_{n-1}(s)), f(s, x_{n-2}(s))) \leq 2M$ on $\mathbb{E}_0$. Note that the last obtained result can be made less than $\epsilon > 0$ provided that $|t_2 - t_1| < \delta = \left(\frac{\epsilon\Gamma(1+q)}{4M}\right)^{\frac{1}{q}}$. This leads to obtain:

$$|\phi(t_1) - \phi(t_2)| \leq \epsilon,$$

which proves the continuity of $\phi(t)$. Similar discussion holds for continuity of $\widehat{\phi}(t)$, hence it is omitted. Please notice that the idea of using mentioned uniqueness theorems was discussed in the deterministic case for fractional differential equations in [10, 11, 12].