Abstract: The Standard Model of particle physics has proven to be an exceptionally effective framework in explaining a wide array of experimental observations, however, several fundamental questions remain unresolved. These include the incorporation of gravity into the Standard Model framework, the stability of the Higgs boson mass against radiative corrections, the origin of matter-antimatter asymmetry, and the identification of dark-matter candidates. One potential avenue to address these limitations involves extending the Standard Model by introducing an additional Higgs doublet. This study investigates the existence of a heavy neutral scalar (H) or pseudo-scalar (A) Higgs boson, as predicted by the two-Higgs-doublet model. The analysis presented in this thesis focuses on scenarios where such particles are produced in association with a top-quark pair ($t\bar{t}H/A$) and subsequently decay into a pair of top quarks ($H/A \rightarrow t\bar{t}$). This results in a four-top-quark ($t\bar{t}t\bar{t}$) final state. Proton-proton collision data collected during Run 2 (2015-18) at a center-of-mass energy of 13 TeV, recorded by the ATLAS detector at the Large Hadron Collider, are utilized for this search. Events are selected based on the presence of exactly one or two oppositely charged leptons (electrons or muons) in the final state. Data-driven corrections are applied to refine the modelling of the dominant background process, top-antitop production with additional jets, and a state-of-the-art graph neural network is employed to enhance signal-to-background discrimination. The results are combined with a prior ATLAS search in the multilepton channel to set upper limits on the $t\bar{t}H/A \rightarrow t\bar{t}t\bar{t}$ production cross-section for H/A in the mass range of 400 GeV to 1000 GeV, in the alignment limit. Furthermore, constraints are placed on a theoretical model that predicts the production of a colour-octet scalar (commonly known as sgluon) that decays into top-quark pairs ($S_8 \rightarrow t\bar{t}$).