The thesis is devoted to study of continuum mechanics and thermodynamics and the related mathematical analysis. It consists of four self-contained chapters dealing with different aspects.

The first chapter focuses on peridynamics, a non-local theory of continuum mechanics, and its relation to conventional local theory of Cauchy-Green elasticity. Similar comparisons has been used for proving consistency and for determining some of the material coefficients in peridynamics, provided the material parameters in the local theory are known. In this chapter the formula for the non-local force-flux is computed in terms of the peridynamic interaction, relating the fundamental concepts of these two theories and establishing hence a new connection, not present in the previous works.

The second and third chapters are both devoted to Rate-Independent Systems (RIS) and their applications to continuum mechanics. RIS represents a suitable approximation when the internal, viscous, and thermal effects can be neglected. RIS has been proven to be useful in modeling hysteresis, phase transitions in solids, elastoplasticity, damage, or fracture in both small and large strain regimes.

In the second chapter the existence of solutions to an evolutionary rate-independent model of Shape Memory Alloys (SMAs) is proven. The model considers non-convex energies, and is hence suitable for predicting the mechanical response at large strains. Compared to the previous works we weaken the assumptions on the energy functional, using the notion of gradient polyconvexity (GPC), and hence broaden the range of materials that can be modeled.

The third chapter generalizes the concept of local solutions, originally introduced for problems at small strain. As opposed to energetic solutions, they do not force too early jumps and are hence more favorable for predicting damage or fracture. The existence of here defined separately global solutions is proven under hypotheses common in large strain mechanics; energy may be non-convex, depend on the Eulerian gradient of the internal variable, blow up for extreme compression, and the deformations are injective everywhere in the domain.

The last chapter of the thesis is devoted to fundamentals of continuum mechanics and thermodynamics. It tries to provide a partial answer to the question how the theory should be constructed, taking models of anisotropic visco-elastic fluids as an accompanying example. It shows it is not necessary to abandon the variational principles (least action or Hamiltonian mechanics), because they lead to reversible and non-dissipative systems; instead they can be successfully modified, yielding then an evolution that dissipates energy and is compatible with the laws of thermodynamics; a particular example of such a generalization being the General Equation for Non-Equilibrium Reversible-Irreversible Coupling (GENERIC).